The Status of Black Rockfish (*Sebastes melanops*)

Off Oregon and Northern California in 2003

Stephen Ralston and E. J. Dick

National Marine Fisheries Service
Southwest Fisheries Science Center
110 Shaffer Road
Santa Cruz, California 95060

NMFS Santa Cruz Laboratory
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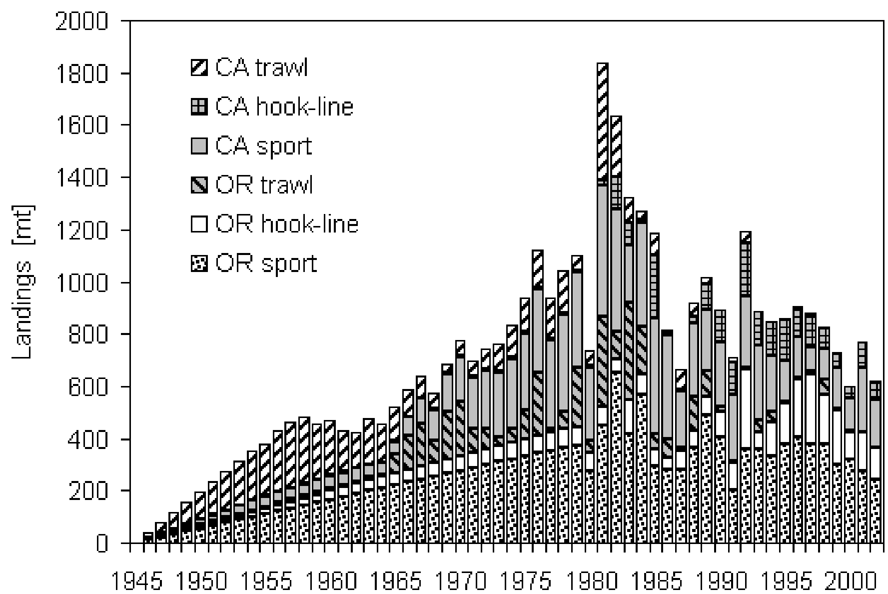
Executive Summary

Stock: This assessment pertains to the black rockfish (*Sebastes melanops*) population resident in waters located off northern California and Oregon, including the region between Cape Falcon and the Columbia River. Genetic information is presented that indicates black rockfish within that area represent a single homogeneous unit. A separate analysis of black rockfish off the coast of Washington and Oregon north of Cape Falcon was conducted by Wallace *et al*. (1999).

Catches: Catches of black rockfish from Oregon and California were classified into 6 distinct fisheries, i.e., the recreational, commercial hook-and-line, and trawl sectors from each State. Since 1978, when consistent catch reporting systems began, landings have ranged from 602–1,836 mt. From 1978-2002 recreational catches have been reasonably consistent and have predominated. Concurrently, hook-and-line landings have increased as trawl landings have decreased. For this assessment, catches from 1945-77 were estimated from fragmented data and were ramped up by linear interpolation to known values in 1978.

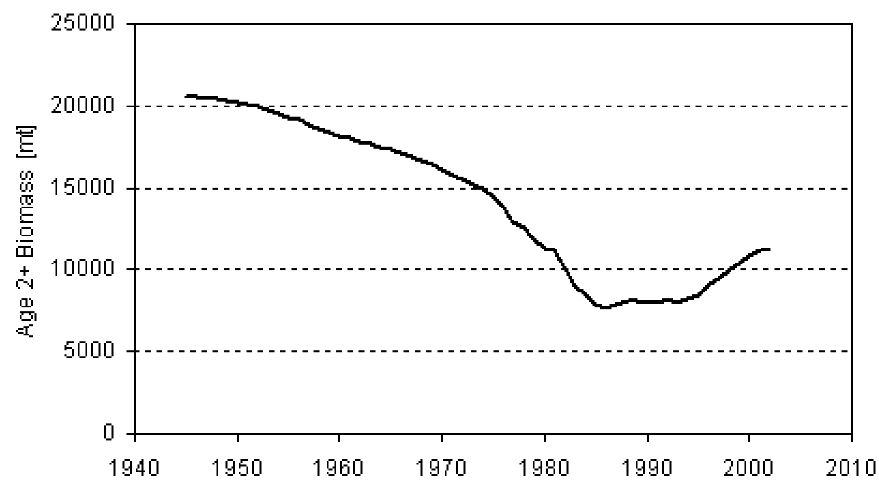


Data and Assessment: A variety of data sources was used in this assessment including: (1) recreational landings, age, and size composition data from the Oregon Department of Fish and Wildlife (ODF&W), (2) recreational landings (all California and Oregon shore-based modes) from the RECFIN data base, (3) Oregon commercial landings (trawl and hook-and-line) from the PACFIN data base, (4) size compositions for the commercial fisheries in Oregon from ODF&W, (5) California commercial landings and length compositions from the CALCOM database, (6) a recreational catch-per-unit-effort (CPUE) statistic developed from information provided by ODF&W, (7) recreational CPUE statistics for each State derived from the RECFIN data base, and (8) a recreational CPUE statistic developed from the CDF&G central California CPFV data base. These multiple data sources were combined in a maximum likelihood statistical setting using the length-based version of the Stock Synthesis Model (Methot 1990, 2000).

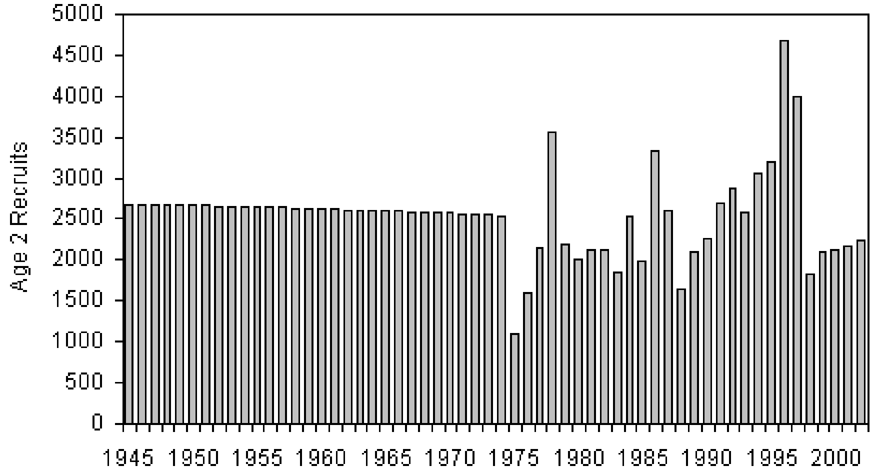
Unresolved Problems and Major Uncertainties: The major sources of uncertainty in this stock assessment include: (1) the amount of historical landings that occurred prior to the 1978, (2) the assumed natural mortality rate, and (3) the steepness of the spawner-recruit curve.

Reference Points: Based on the Pacific Fishery Management Council's current default harvest rate policy for *Sebastes*, the target harvest rate for black rockfish is $F_{50\%}$. Given the life history of the species, and the prevailing mix of fisheries in 2002 (predominately recreational with some commercial hook-and-line catches), this corresponds to an exploitation rate of about 7.7%. Moreover, the Council's current target biomass level for exploited groundfish stocks is $B_{40\%}$, i.e., the spawning output of the stock is reduced to 40% of that expected in the absence of fishing. For black rockfish that corresponds to spawning output of 1.258×10^9 larvae.

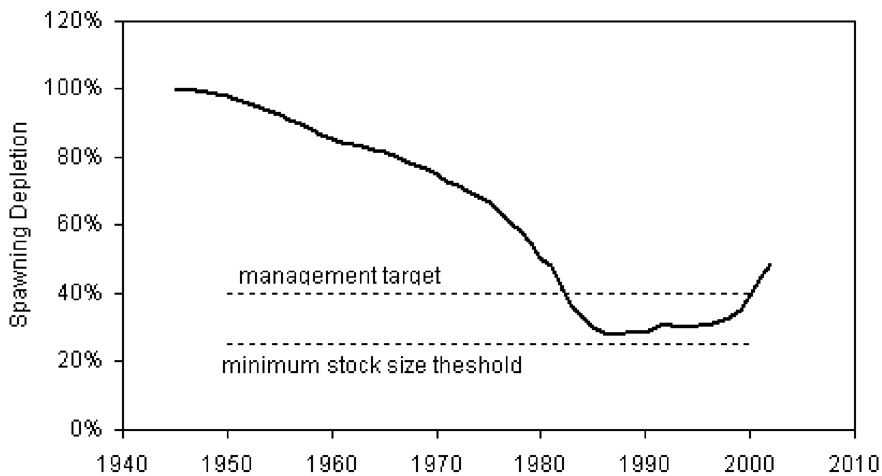
Stock Biomass: The biomass of age 2+ black rockfish underwent a significant decline from a high of 20,510 mt in 1945 to a low of 7,702 mt in 1986, representing a 62% decline. Since that time, however, the stock has increased and is currently estimated to be 11,232 mt. Most of the population's growth occurred after 1995, due to several large recruitment events, including especially the 1994 and 1995 year-classes.



Recruitment: In the assessment recruitment was treated as a blend of deterministic values (i.e., 1945-1974 & 1999-2002) and stochastic values (i.e., 1975-1998). The Beverton-Holt steepness parameter (***h***) was fixed at a value of 0.65, based upon on a profile of goodness-of-fit and results from a prior meta-analysis of rockfish productivity. During the 1975-1998 period there was a significant increasing trend in recruitment, even as spawning output declined. That trend culminated with the recruitment of the 1994 and 1995 year-classes, which were about twice as large as expected, based on the predicted value from the spawner-recruit curve.



Exploitation Status: The northern California-Oregon stock of black rockfish is in healthy condition, with 2002 spawning output estimated to be 49% of the unexploited spawning level. This places the stock well above the management target level of $B_{40\%}$. Likewise, age 2+ biomass in 2002 is estimated to be 11,232 mt, which is 55% of that expected in the absence of fishing.



Management Performance: Black rockfish in the southern area (Eureka & Monterey INPFC areas) have historically been managed as part of the "Other Rockfish" category, with no explicit ABC or OY designated. For 2001 the ABC of all species within that group was 2,702 mt. In contrast, in the northern area (Vancouver & Columbia INPFC areas) black rockfish is managed within the "Remaining Rockfish" category, with a designated 2001 ABC of 1,115 mt.

Forecasts: A forecast of stock abundance and yield was developed under the base model. In this projection there was no 40:10 reduction in OY from the calculated ABC because the stock is estimated to be above the management target ($B_{40\%}$) and annual yields were calculated using an $F_{50\%}$ exploitation rate (see above). Results are shown in the following table:

Year	Age 2+ Biomass	Spawning Output	Recruits	Exploitation Rate	Total Yield [mt]
2003	11,342	1.63E+09	2,307	7.60%	802
2004	11,217	1.66E+09	2,353	7.45%	775
2005	11,082	1.65E+09	2,386	7.34%	753
2006	10,938	1.62E+09	2,394	7.29%	736
2007	10,802	1.57E+09	2,392	7.28%	725
2008	10,700	1.53E+09	2,381	7.29%	719
2009	10,621	1.50E+09	2,366	7.30%	715
2010	10558	1.48E+09	2,354	7.32%	713
2011	10505	1.47E+09	2,343	7.34%	711
2012	10459	1.46E+09	2,335	7.35%	708

Decision Table: The amount of historical catch prior to 1978 was considered a major source of uncertainty in this assessment. Although some catch estimates were available prior to that time, which were not inconsequential, no continuous time series of catches from the sport and trawl fisheries in Oregon and California could be identified. Therefore, the catch record was assumed to begin in 1945, with no historical catches prior to that year. Catches were then made to ramp up to 1978, using whatever external data were available and linear interpolations to fill missing values. To bracket uncertainty in these catches and their effect on the management system: (1) high and low catch scenarios were created, (2) the base assessment model was refitted to each series, and (3) 10-year yield projections run. Results show that if historical catches were lower than in the base model the calculated OY (= ABC) is reduced. Conversely, if historical catches were higher than modeled the OY would be higher. For purposes of comparison, total catches for 2000, 2001, and 2002 were 602, 768, and 617 mt, respectively.

	Low Catch Scenario		Base Model		High Catch Scenario	
Year	OY [mt]	Depletion	OY [mt]	Depletion	OY [mt]	Depletion
2003	757	54.2%	802	51.9%	886	48.1%
2004	729	54.9%	775	52.7%	861	49.0%
2005	706	54.5%	753	52.5%	842	48.9%
2006	688	53.3%	736	51.4%	828	48.2%
2007	676	51.7%	725	50.0%	820	47.1%
2008	668	50.3%	719	48.8%	817	46.2%
2009	663	49.2%	715	47.9%	816	45.6%
2010	660	48.3%	713	47.2%	816	45.1%
2011	657	47.7%	711	46.7%	816	44.9%
2012	654	47.2%	708	46.3%	816	44.7%

Research and Data Needs: The black rockfish review panel identified certain gaps in the available information that hindered the stock assessment. These were: (1) a fishery-independent survey should be developed to monitor changes in black rockfish population abundance, (2) the California CPFV data set should be more thoroughly investigated to ascertain whether or not serial depletion of fishing sites has artificially kept catch rates high [see Appendix 1], (3) a standard approach to historical catch reconstructions should be developed, (4) the possibility of time-varying growth should be investigated, and (5) the calculation of the RECFIN catch-per-unit-effort statistic should be more thoroughly analyzed and verified.

Introduction

Black rockfish (*Sebastes melanops* = "magnificent black face"), also known as bass, black bass, black snapper, gray rockfish, and snapper, is a midwater/surface-dwelling member of the family Scorpaenidae, which is usually found schooling in water over submerged rocky reefs, often in the company of yellowtail (*S. flavidus*), dusky (*S. ciliatus*), silvergray (*S. brevispinis*), and blue (*S. mystinus*) rockfishes (Love 1996). Unlike some of the rockfishes (genus *Sebastes*), mature black rockfish are not strongly site attached, with tagging studies indicating movements of up to several hundreds of miles. The species feeds on a wide variety of foods, including mysid shrimps, krill, juvenile rockfishes, sandlance, zooplankton, etc. (Love 1996). Young-of-the-year juveniles are an important prey of other fishes, sea birds, and marine mammals.

Black rockfish, like all other rockfishes, is primitively viviparous (livebearing), with parturition of larvae occurring in the winter months of November-March (Wyllie-Echeverria 1987). The late-stage larvae transform into a pelagic juvenile stage at a size of about 25 mm and remain pelagic for periods of up to 5-6 months. Settlement occurs in nearshore, shallow-water habitats that contain adequate structural relief for sheltering the newly settled young-of-the-year (e.g., tidepools, etc). Due to the extended pelagic larval and juvenile stages, there is likely substantial export of recruits to localities other than where spawning occurred.

Black rockfish is the most important "rockcod" species in the recreational fisheries of Washington, Oregon, and northern California, comprising over a third of the total marine recreational catch in some areas (Love 1996). It is not uncommon to catch the species incidentally while trolling for salmon (Eschmeyer *et al*. 1983, Wallace *et al*. 1999). Other fisheries responsible for the harvest of black rockfish include the commercial trawl fishery, which historically was significant but since the 1990s has declined in importance, and the commercial hook-and-line fishery, which has largely replaced the trawl fishery.

The regulatory history of black rockfish is complicated because the species has been managed as part of the "*Sebastes* complex" (PFMC 2000). Consequently the black rockfish allowable biological catch (ABC) has been added together with the ABCs of eleven other minor species of "remaining rockfish" and all "other" rockfish. The optimum yield (OY) is the target to which the fishery is managed, and is based upon the combined ABCs of the various elements within the *Sebastes* complex (Table 1).

Wallace *et al*. (1999), following on the work of Wallace and Tagart (1994) and Stewart (1993), assessed the status of the black rockfish resource off the coast of Washington and as far south as Cape Falcon, Oregon. They concluded that "black rockfish stock can be characterized as declining in abundance but healthy, i.e., displaying abundance levels in excess of those assumed to promote sustainable production." Specifically, the estimated 1999 stock biomass in the assessed area was 9,500-10,100 mt, depending on assumptions concerning tag reporting rates, but the spawning biomass in 1998 was about double the equilibrium biomass associated with an $F_{45\%}$ harvest rate.

Distribution and Stock Structure

Black rockfish are found from southern California (i.e., San Miguel Island) to Amchitka in the Aleutian Islands (Hart 1988; Eschmeyer *et al*. 1983), but the center of distribution is from northern California to southeastern Alaska. Even so, Weinberg (1994) noted that during the period 1977-92 black rockfish occurred in only 23 of 1,874 hauls (1.2%) that were conducted by the AFSC triennial shelf trawl survey off the coasts of Oregon and Washington. Similarly, Jay (1996) reported that black rockfish was not among the top 33 fishes caught in the triennial survey. The near absence of this species in AFSC trawl surveys is due to its nearshore midwater distribution over rocky reefs and, for this reason, there has been little in the way of fishery-independent information with which to gauge the status of the population.

Wallace *et al*. (1999) reported evidence of a distinct genetic population of black rockfish off the Washington coast, extending south to Cape Falcon, a finding that was used to delineate the unit stock in that assessment. Subsequent work, however, has found little support for a discontinuity in black rockfish genetic structure at Cape Falcon. In particular, Baker (1999) conducted a genetic analysis of 720 black rockfish from 8 localities along the northern half of the Oregon coast, including one site well to the north of Cape Falcon (Cannon Beach). He found no evidence for any substantive constraints on gene flow among sites because, among the 14 polymorphic loci considered, F_{ST} values (a measure of genetic dissimilarity) were all relatively small (0.005-0.029). Moreover, cluster analysis of all the 28 loci he examined indicated that fish from Cannon Beach (north of Falcon) were genetically very similar to samples from Three Arch Rock, Cape Lookout, Pacific City, and Lincoln City (all south of Falcon).

More generally speaking, genetic studies have typically been unable to discriminate among rockfish populations inhabiting the open coastlines of California, Oregon, and Washington. For example, Wishard *et al*. (1980) identified no spatial genetic structure for *Sebastes goodei*, *S. paucispinis*, and *S. flavidus* from samples collected off the coasts of California, Oregon, and Washington. Similarly, no notable difference among samples of *S. alutus* from Oregon and Washington was detected, although samples from the Gulf of Alaska were distinct from the two more southerly locations. However, those authors did report weak evidence of genetic differentiation among samples of *S. pinniger* collected off southern Oregon/California and northern Oregon/Washington, which is consistent with the conclusions of Wallace *et al*. (1999). Lastly, Rocha-Olivares and Vetter (1999) found evidence of two distinct genetic populations of *Sebastes helvomaculatus*, i.e., a southern “stock” found off California, Oregon, and Vancouver Island and a northern stock off southeastern Alaska. This geographical pattern of stock structure is consistent with the findings of Wishard *et al*. (1980) concerning Pacific ocean perch. Thus, in the two situations where clear genetic differences have been observed among sub-populations of *Sebastes*, the boundary separating stocks has been between Vancouver Island and southeastern Alaska. Consequently, based on these studies we find no evidence that Oregon and California populations of black rockfish are genetically heterogeneous, and for the purposes of this assessment we define the unit stock to be the fish distributed within that geographic area, i.e., we treat California and Oregon as the unit stock under analysis. This overlaps to a small degree with assessment of Wallace *et al*. (1999), who included the stretch of coastline between the mouth of the Columbia River and Cape Falcon, a distance of 27 nmi. In contrast, the distance between Point Arena (a fairly arbitrary southern limit of latitudinal distribution in California) and the Columbia River (the northern Oregon border) is about 420 nmi.

Biological Parameters

For this study we obtained length and weight measurements from 1,987 male and 1,873 female black rockfish from personnel at the Oregon Department of Fish and Wildlife (ODF&W, D. Bodenmiller, pers. comm.). After logarithmic transformation, we evaluated the data for sex-specific differences in the length-weight relationship and found none (ANCOVA for differences in slope P = 0.992; ANCOVA for differences in adjusted mean P = 0.980). Consequently, the data were pooled and a single relationship estimated (Figure 1). After back-transformation bias correction, the predictive equation to the arithmetic scale resulted in:

$$W = 1.677\times10^{-5}\ FL^{\ 3.000}$$

where W is weight [kg] and FL is fork length [cm].

A large quantity of age [yr] and fork length [cm] data were available for use in this assessment, particularly from the recreational fishery in Oregon. We used those data to estimate sex-specific von Bertalanffy growth equations for black rockfish using the Schnute (1981) parameterization with τ_1 = 5.0 yr and τ_2 = 15.0 yr. This initial estimation of the black rockfish growth curve was completed external to and prior to any modeling of the stock and was based on 28,453 observations of age, length, and known sex. The results of fitting the data are displayed in Figure 2 and the parameter estimates are provided in Table 2 under the column labeled initial value. Because black rockfish are winter spawners (Wyllie-Echeverria 1987), when fitting the data we assumed a January 1 birthdate for all fish and we therefore added 0.5 yr to each integer age.

We then used the residuals from the fit to estimate variation in the Fork Length (FL) of black rockfish at age. Specifically, each residual was squared and the mean squared deviation was calculated as:

$$\sigma^2_{FL|sex,age} = \frac{\sum_k (FL_{ijk} - \hat{FL}_{ijk})^2}{N_{ij}}$$

where FL_{ijk} is the observed length for sex ***i*** at age ***j*** for specimen ***k***. Sex-specific coefficients of variation (CVs) of length at age were then computed as the ratio of the root-mean-squared error to predicted age and these were then regressed on age for $\tau_1 \leq \text{age} \leq \tau_2$ (Figure 3). Finally, the resulting regression equations were used to predict the CVs of male and female fish at ages 5 and 15 yr (Table 2).

Wyllie-Echeverria (1987) provided information on the maturity of black rockfish from northern California. In particular, she estimated the parameters of a logistic relationship between the proportion mature and total length [cm]. For use here, those results were expressed in terms of FL by employing the linear transformation provided in Echeverria and Lenarz (1984).

Similarly, Bobko and Berkeley (unpubl.) provide logistic parameter estimates for the relationship between maturity and FL [mm] for fish sampled in Oregon. Both studies were based on histological examination of ovaries and both indicate that black rockfish are 50% mature at a size of about 39 cm FL. However, the Wyllie-Echeverria curve ascends more slowly than the Bobko-Berkeley relationship (Figure 4). Because the inflection points are virtually identical, in practice we expect a negligible difference in result from applying the two curves. For example, a simple spreadsheet evaluation of the effect of using different maturity slope parameters shows that a 1% change in slope parameter value induces only a 0.036% change in spawning biomass, an insensitive dependence. Even so, for this assessment we calculated a maturity schedule based on the average expected maturity from the two studies and fitted a logistic curve to the mean. Specifically, we employed the following female logistic maturity relationship in the stock assessment:

$$P = \frac{1}{1 + e^{-0.4103(FL - 39.53)}}$$

where P is the proportion of females that are mature and FL is fork length [cm].

Bobko and Berkeley (unpub.) also present information on the fecundity of black rockfish from Oregon. Their data, which are based on an examination of 263 mature females collected from Depoe Bay, Newport, Charleston, and Port Orford, indicates there is a significant relationship between weight-specific fecundity (Φ, larvae/kg) and female weight (Figure 5; $P < 0.0001$). If this relationship is assumed to be linear, the linear regression equation relating weight-specific fecundity to weight is:

$$\Phi = 289{,}406 + 103{,}076\ W$$

This result implies that the spawning output of black rockfish is not directly proportional to spawning biomass. An age structure shifted towards older, larger fish (e.g., an unexploited population) would have greater spawning output than a population shifted towards younger, smaller fish, even if the biomass of spawning females were the same. Both parameters were then re-scaled (division by 1,000) to prevent numerical overflows within the model. As a consequence the egg output from the model should be multiplied by 10^3 to obtain the absolute spawning output.

Landings

Landings estimates for the contemporary period (1978-2002) were obtained from four different sources. For the northern California recreational fishery, information contained in the RECFIN data base (http://www.psmfc.org/recfin/data.htm) provided landings estimates for the period 1980-2001, excluding the 1990-92 time period when the MRFSS program went unfunded. Landings for that period were interpolated from the catch statistics reported in 1989 and 1993. Moreover, to extend the time series to 1978 (i.e., the initial starting year of the model) the catch in 1978 and 1979 was assumed to be equal to the average catch from 1980-83. Similarly, the catch in 2002 was assumed equal to the average catch for the three preceding years (1999-2001).

Landings estimates for both the California commercial hook-and-line and trawl fisheries from 1978-2001 were extracted from the CALCOM data base maintained at the Santa Cruz Laboratory, SWFSC. Landings for 2002, the last year of the model, were assumed equal to the 2001 catch (i.e., hook-and-line fishery = 67 mt and trawl fishery = 2 mt).

For the Oregon recreational fishery, data were provided by the Oregon Department of Fish & Wildlife (ODF&W), representing the estimated catch in numbers of black rockfish taken in the ocean boat fishery from 1979-2002 (D. Bodenmiller, pers. comm.). Those estimates were then converted to annual catch weights using year-specific estimates of the mean weight of fish caught, derived from annual length composition samples (see below) and the length-weight regression described above. For completeness, we note that the catch of black rockfish from shore-based modes of fishing in Oregon was obtained from the RECFIN data base and added to the ODF&W ocean boat catch estimates, although shore-based modes accounted for less than 2% of the State's recreational catch. Oregon sport landings in 1978 were assumed to be equal to the average of the 1979-81 catch. Likewise, the 2002 catch was estimated by ratio with the 1998-2001 reported RECFIN catch and the 2002 RECFIN estimate.

Initially, information regarding 1982-2002 Oregon commercial hook-and-line landings was derived from the PACFIN data base, as provided by ODF&W (M. Freeman, pers. comm.). For the assessment landings from "hook-and-line," "bottom longline," and "troll" gears (hook-and-line) were pooled in this summary. However, an examination of the data for the period 1982-89 indicated they were quite noisy and/or erratic and, as a consequence, the STAR panel recommended that landings for that time period be obtained by ratio estimate from the Oregon aggregate hook-and-line "rockfish" catch. Results provided by ODF&W staff during the STAR panel meeting showed that during the period 1990-2000 black rockfish accounted for 28.6% of rockfish landings. Consequently, that ratio was applied to the total hook-and-line rockfish catch from 1982-89 to provide annual estimates of black rockfish catch from that fishery for those years. Finally, landings for the period 1978-81 were estimated as the average landings from 1982-89 period (i.e., 72.2 mt/yr).

Trawl landings from Oregon (1982-2002) were also obtained from the PACFIN data base (M. Freeman, pers. comm.). Landings from shrimp trawl and bottom trawl gears were pooled into a single "trawl" category. Kupillas (unpub.) developed independent estimates of black rockfish catch by gear type for the period 1994-2000 and his data agree well with the PACFIN information, differing by only 1.4% in aggregate. To estimate landings for 1978-1981 results from Wallace *et al*. (1999) were utilized. They provided trawl landings estimates that started in 1963 for the State of Washington, which demonstrated a good correlation with Oregon landings over the period 1982-98. Therefore, the ratio of Oregon to Washington cumulative catch (69.5%) from that time period was used to estimate Oregon landings for years prior to 1982.

We have summarized these various landings data/estimates in Table 3 and Figure 6. Note that six distinct fisheries are identified, i.e., recreational (sport), hook-and-line (HKL), and trawl (TWL) from each State (Oregon and California). Overall, over the period 1978-2002, the sport fisheries have taken most of the catch (65%), followed by the commercial hook-and-line fisheries (21%), and trawl fisheries (14%). Note that there has been a definite shift in the commercial fisheries from trawl landings to hook-and-line landings over this time period.

Results show thatlandings peaked in 1981 with estimated landings of 1,835 mt. In recent years, annual combined black rockfish landings from both States have been in the 600-800 mt range.

Historical Catch

During the STAR panel review the amount of harvest that occurred in years preceding 1978 became a focal point of discussion. Initial modeling results showed that the amount of "historical catch" had a strong affect on the estimated depletion level of the stock. Moreover, in preliminary runs of the Stock Synthesis model, catch prior to 1978 was treated using the HISTCAT option, i.e., the estimated catch from the stock between the unexploited virgin level and the equilibrium level that occurred just prior to the modeled era. In addition, selectivity during the historical period was initially treated as knife-edge at age 1. However, due to concerns expressed by the STAR panel about the effect of an abrupt transition from an equilibrium stock age composition based on a single simplistic selectivity curve, to a non-equilibrium composition in 1978 based on 6 complex selectivity curves, the modeled era was extended backwards in time to start in the year 1945. As part of this exercise, black rockfish catches prior to 1946 were assumed to be zero. However, starting the model in 1945 with zero catch required the estimation of time series of landings for each of the six modeled fisheries from 1946-77. To accomplish this a number of outside sources were consulted.

Results presented in Nitsos (1965) provided annual estimates of black rockfish landings in the California trawl fishery for the years 1954-63. Likewise, Gunderson *et al.* (1974) provided annual estimates of California trawl landings for the period 1969-73. To fill in the missing years in the California trawl time series we used linear interpolation, i.e., 1946-53, 1964-68, and 1974-77. For the Oregon trawl fishery from 1963-77, landings were estimated using the Wallace *et al*. (1999) ratio described above (Oregon catch = 69.5% of the Washington catch). For the earlier period (1946-62), landings were linearly interpolated to zero in 1945.

Because the commercial hook-and-line fisheries from both Oregon and California developed largely after 1986, as the trawl fisheries waned, we assumed that landings from those two fisheries could be estimated by linear interpolation between a zero catch in 1945 and the estimated landings in 1978 (72.2 and 7.3 mt, respectively; Table 3).

The only available information that we could uncover regarding recreational catches of black rockfish prior to 1978 in the States of Oregon and California came from Miller and Gotschall (1965) and Young (1969). Findings gleaned from those two references allow one to infer landings estimates of black rockfish in the California sport fishery for the years 1955, 1960, and 1965, which only ranged 38.8–47.3 mt/year. We therefore interpolated all missing values in the California sport time series, i.e., between 1946-1954, 1956-1959, 1961-1964, and 1966-1977 (assumed zero catch in 1945). Likewise, anecdotal information from Oregon indicates that during the 1950s and 1960s the sport catch was much lower than that observed during the early 1980s (D. Bodenmiller, pers. comm.). Hence we interpolated all Oregon sport landings estimates and assumed a linear increase in catch from zero 1945 to 365.0 mt in 1978 (Table 3).

This reconstruction of historical black rockfish catches prior to 1978 is highly uncertain and, as a consequence, the overall sensitivity of the stock assessment was evaluated by conducting a decision analysis that incorporated a likely range of possible alternatives to the catch reconstruction presented here (Figure 6; see also Tables 14 and 15).

Age and Length Compositions

The Oregon Department of Fish & Wildlife has engaged in the collection of specimen data from the State's recreational fishery since 1978. A comprehensive data set was made available for use in the assessment (D. Bodenmiller, pers. comm.), which included 31,061 age determinations from sexed fish. In the early years of the ODF&W survey, sampling effort was much less than in recent years, primarily because collections from 1978-89 were limited to the port of Garibaldi, but throughout the 1990s over 1,000 fish have been aged and lengthed each year.

An examination of black rockfish sex ratio as a function of age shows that starting around age 10 yr, the representation of females in the older age categories falls from about 50% to about 10-20% by age 20 yr (Figure 7). This finding is consistent with results presented in Figure 2, which shows that female black rockfish do not live much beyond 25 yr, whereas males have about an additional 10 years of life expectancy. In combination, these two results indicate that females may experience a higher mortality rate than males.

An examination of the Garibaldi age and length data showed that fish from that port were on average larger than fish taken elsewhere. Consequently, the data from 1978-89 were excluded from further use in the stock assessment, which reduced the age/length sample size from 31,061 to 26,278 fish. The age data were then pooled into frequency distributions by sex and year (1990-2001), and expressed as annual percent distributions for the combined sex sample (Table 4, Figure 8). Note that fish over 20 yr old are quite uncommon in the data and an accumulator age of 25+ was used to aggregate the oldest fish in the assessment model.

Similar to the age data, ODF&W provided an extensive data base containing length measurements of fish captured in the Oregon ocean boat recreational fishery (D. Bodenmiller, pers. comm.). Those data represented 33,468 fork length (FL) measurements from individually sexed fish. In addition, a substantial quantity of length measurements (N = 41,520 fish) was obtained from the RECFIN data base (W. Van Buskirk, pers. comm.), although those fish were unsexed. In order to utilize both sets of data, we compared the aggregated length composition of black rockfish for the years where both programs sampled (1980-89 and 1993-2001). Results show that the two programs sample fish of similar length structure (Figure 9). Consequently, the data were pooled, after deleting the Garibaldi fish (see above). This reduced the combined sample size to 70,179 measured fish. Using the ODF&W data, we then estimated the sex ratio of black rockfish by length interval for the years 1990-2001 and applied those rates to the unsexed RECFIN data to decompose those samples into sex-specific data. However, because RECFIN was the only source of samples for the years 1980-89 and 2002, those data were entered into the stock assessment model as unsexed fish (Table 5, Figure 11), while the length data for 1990-2001 were assembled into sex-specific length frequency vectors (Table 5, Figure 12). These figures shows that in the Oregon sport fishery between 1978-2002, all fish were in the range 20 cm $\leq$ FL $\leq$ 60 cm. Therefore, in the stock assessment model fish were classified into 2 cm length bins within that size range.

Information provided by ODF&W (M. Freeman, personal communication) allowed a description of the sex-specific length composition of black rockfish taken in the Oregon hook-and-line and trawl fisheries. Specifically, length measurements from 2,390 male and 2,098 female fish were provided from samples taken in the former fishery and 172 males and 123 females were measured from samples acquired in the latter fishery. In addition, adjusted "hail" weights for the sampled trips were provided, and these were used in expanding the sample data to trip totals. Finally, the expanded sex-specific length data for the Oregon hook-and-line fishery was summarized as sex- and year-specific length-frequency compositions using the combined sex annual total as the denominator (Table 6, Figure 13). However, due to the sparseness of the data the sexes were combined in the trawl fishery calculations (Table 7, Figure 14).

Information on the size distribution of black rockfish in the California recreational fishery was obtained from the RECFIN sampling program (W. Van Buskirk, pers. comm.), including length measurements from 18,641 fish. In addition, the California Department of Fish & Game (CDF&G) sponsored a Commercial Passenger Fishing Vessel (CPFV) survey from 1987-98 (D. Wilson-Vandenberg and H. King, pers. comm.) that includes information on the lengths of black rockfish captured in the central and northern California recreational fishery (N = 8,959). As was the case for the Oregon recreational data, the RECFIN data were compared directly with the State agency data (CDF&G CPFV survey) to evaluate whether the length data could be aggregated. Results showed that the two sources of information were reasonably similar (Figure 10) and so they were combined. Next the data were condensed into unsexed length-frequency vectors, which were input as data into the model (Table 8, Figure 15).

Annual length compositions of black rockfish taken in the California commercial hook-and-line and trawl fisheries were acquired from the CalCOM data base maintained at the Santa Cruz Laboratory (Pearson and Erwin 1997). For the assessment the two sexes were combined in the model due to low sample size (Tables 9 & 10). Note that for the hook-and-line fishery, we had data for the years 1982-85, 1992-2002 and results showed (Figure 16) that the modal size of the catch in that fishery is about 40 cm FL. In contrast, fish taken in the California trawl fishery are larger (mode ~ 46 cm FL), although the available data are more sparse and the compositions are substantially noisier (Figure 17).

Recreational Catch Per Unit Effort

We used the RECFIN data base from 1980-89 and 1993-2002 to construct a catch-per-unit-effort statistic for black rockfish. The analysis was partitioned to create separate time series of relative abundance for the Oregon and Northern California recreational fisheries. Because RECFIN data lacks good information on the species complex targeted during a fishing trip, we determined the extent of co-occurrence of black rockfish with other species and used species composition to predict the probability of catching black rockfish by trip. In particular, we first created a subset of the data representing the $\boldsymbol{k}$ species that accounted for at least 0.2% of the data. We then defined a new binary variable (X_{ij}) to represent the coded abundance of species $\boldsymbol{i}$ during fishing interview $\boldsymbol{j}$ (absent = 0, present = 1) and calculated a linear sum as:

$$\Phi_j = c_0 + \sum_{i=1}^{k} c_i X_{ij}$$

where the $\boldsymbol{c_i}$ are estimated species-specific coefficients and $\boldsymbol{c_0}$ is an intercept term. The Φ_j were then inverse logit-transformed, i.e.,

$$\Lambda_j = \frac{\exp(\Phi_j)}{1 + \exp(\Phi_j)}$$

to re-scale the Φ_j to probabilities [$0.0 \leq \Lambda_j \leq 1.0$]. In particular, when black rockfish were caught during a trip we defined $p_j = \Lambda_j$ to be the predicted probability of co-occurrence, whereas when they were not observed we defined $p_j = 1 - \Lambda_j$. Finally, the total log-likelihood of the data ($\mathcal{L}$), given the set of coefficients $\{c_0, c_i\}$ was calculated as:

$$\mathcal{L} = \sum_j \log(p_j)$$

which was maximized by numerical search over the $\{c_0, c_i\}$.

Results for Oregon (Figure 18) show that, excluding black rockfish, 22 species were included in the analysis of trip species composition. Of these, cabezon (*Scorpaenichthys marmoratus*), blue rockfish (*Sebastes mystinus*), and copper rockfish (*Sebastes caurinus*) showed a relatively high probability of being caught when black rockfish were observed ($c_i > 2.0$). Conversely, king salmon (*Oncorhynchus kisutsch*), widow rockfish (*Sebastes entomelas*), and Pacific halibut (*Hippoglossus stenolepis*) showed a low probability of co-occurrence with black rockfish ($c_i < -2.0$). A comparable graphic for northern California (Figure 19) shows that black rockfish in that region are closely associated with cabezon and black-and-yellow rockfish (*Sebastes chrysomelas*) and not with chilipepper (*Sebastes goodei*) and king salmon (*Oncorhynchus tshawytscha*).

The non-black rockfish species composition during each trip was then used to predict the probability of capturing black rockfish and the actual catch rate of black rockfish was expressed as fish · angler-trip^{-1} (including zero catches). The data were fit to two Generalized Linear Models as suggested by Stefansson (1996), i.e., a binomial GLM with logit-link to estimate the proportion of trips that were positive for black rockfish and a Gamma GLM with log-link to estimate the catch rate of black rockfish in positive trips. Factors in the two GLMs were year and bimonthly period (wave) and the predicted probabilities of capturing black rockfish were used to weight the observations.

For the former (binomial GLM with logit-link), the probability of a positive observation is estimated using a logistic regression model:

$$\log\left(\frac{\pi_i}{1 - \pi_i}\right) = x_i^T \beta$$

To fit this model, the response variable in the data set is re-coded as either 1 or 0, for positive and zero observations, respectively. The probability of a positive observation in, say, a given year is calculated as follows:

$$\pi_y = \frac{\exp(\alpha + \beta_y + \delta)}{1 + \exp(\alpha + \beta_y + \delta)}$$

where π_y is the vector of probabilities for the 'year' factor, α is the model intercept term, β_y is the vector of regression coefficients for the 'year' factor, and δ is the sum across mean effects for each factor other than 'year'.

For the latter model (Gamma GLM with log-link), if the positive observations are assumed to follow a Gamma distribution, the mean response (conditional on observations being positive) is modeled by

Y_i ~Gamma(μ, υ), with mean, μ, and shape parameter υ

$$\log(\mu_i) = x_i^T\beta$$

The back-transformed year effects are then calculated by the equation:

$$\mu_y = \exp(\alpha + \beta_y + \delta)$$

where μ_y is the vector of effects corresponding to each level of the 'year' factor, while α, β_y, and δ are interpreted as in the binomial GLM, above.

The final index of abundance (CPUE statistic) is simply the product of the probabilities from the binomial GLM and the mean responses for non-zero observations, obtained from the Gamma GLM:

$$I_y = \pi_y \cdot \mu_y$$

Standard errors for the delta-GLM index were estimated using a jackknife routine. If we symbolize the delta-GLM function by $\hat{\theta} = \hat{\theta}(X_1, \ldots, X_n)$, for ***n*** observations, and let $\hat{\theta}_{(i)} = \hat{\theta}(X_1, .., X_{i-1}, X_{i+1}, .., X_n)$, then the 'jackknife mean' is simply:

$$\hat{\theta}_{(\bullet)} = \sum_{i=1}^{n} \frac{\hat{\theta}_{(i)}}{n}$$

The jackknife estimate of the standard error is defined as:

$$\hat{\sigma}_J = \left[\frac{n-1}{n} \sum_{i=1}^{n} (\hat{\theta}_i - \hat{\theta}_{(\bullet)})^2 \right]^{1/2}$$

In our analysis of black rockfish catch rates from the RECFIN data we weighted each trip observation by the probability of black rockfish being caught, given the species composition of the trip (see description of the p_j above). A pre-specified vector of weights, equal in length to the number of observations, can be incorporated into the GLM function. The weights, however, were only applied to the mean responses conditional on positive observations (i.e., the Gamma GLM). The Binomial GLM retained equal weighting among observations.

Results for Oregon (Figure 20) show that the estimated catch rate of black rockfish was highest in the first two years of the sampled period (1980 and 1981), but overall there has been little trend in the time series. Note that the jack-knifed standard error estimates show that the precision of the estimates is quite good. Similarly, results for northern California (Figure 21) show little trend in the index over the 1980-2002 time period and lower statistical precision.

In addition to the analysis of RECFIN catch and effort data, a statistic representing the catch rate of black rockfish in the Oregon sport fishery was developed from information provided by personnel at the ODF&W (D. Bodenmiller, personal communication). In particular, those data were used to calculate catch rates of black rockfish in the Oregon ocean-boat recreational fishery. Information in the file included the following variables: (1) year, (2) port, (3) month, (4) trip type, (5) estimated boats, (6) estimated anglers, and (7) estimated catch. We analyzed those data in a simple ANOVA to estimate annual catch rates of black rockfish in the fishery. Specifically, the model we finally adopted was:

$$\log_e(\text{catch/boat})_{ijk} = Y_i + P_j + M_k + \epsilon_{ijk}$$

where "catch" and "boat" are aggregated statistics from each year-port-month stratum, $\boldsymbol{Y_i}$ is the year effect {i = 1979-86, 1999-2002}, $\boldsymbol{P_j}$ is a port effect {j = Astoria, Bandon, Brookings, Coos Bay, Depoe Bay, Florence, Garibaldi, Gold Beach, Newport, Port Orford, Pacific City, Winchester Beach}, $\boldsymbol{M_k}$ is a month effect {k = January-December}, and $\boldsymbol{\epsilon_{ijk}}$ is a normal error term with mean zero and variance σ^2. Note that, due to the aggregated nature of the data, no more than one observation was available for each cell in the ANOVA classification.

We used the number of boats, as opposed to the number of anglers, as the effort statistic, although in practice it made little difference which effort statistic was used. We logarithmically transformed the dependent variable because the resulting multiplicative model under back-transformation was well behaved. Also, because the data were aggregated into year-port-month strata, there were no zero CPUE values in the data set and no additive constant was needed for log-transformation.

The resulting "General" Linear Model was based on the analysis of N = 526 records, with 34 parameters estimated for the 12 years, 12 ports, and 12 months listed above. The full model was highly significant ($P < 0.0001$) with a total $r^2 = 0.51$. Moreover, all three factors in the model (year, port, and month) were highly significant ($P < 0.0001$).

For use in modeling the stock's trajectory, year effects were back-transformed with bias-correction to the arithmetic scale. The resulting time series is shown in Figure 22, where it is apparent that catch rates, which initially were about 40 fish·boat^{-1} in 1979-80, rose rapidly to relatively high rates of about 70 fish·boat^{-1} from 1981-86 and remained high during the latter part of the 1990s and into the new millennium.

We also estimated a black rockfish CPUE statistic developed from the CDF&G central California CPFV data base (D. Wilson-Vandenberg, personal communication). Those data span the 1988-98 time period and include information on the actual locations of catch during fishing trips. Consequently, the data were filtered to include only those locations that produced black rockfish on at least 5 separate occasions (cutoff values of 3, 10, and 15 occasions were also evaluated). Upon determination of sites that could reasonably be expected to produce black rockfish the data were analyzed using a delta-gamma GLM model with year, location, and month factors (see section on RECFIN abundance statistics above). Results suggest (Figure 23) a minor increase in the catch rate of black rockfish from 1988-98, although the jackknife error estimates are relatively greater than for the other three CPUE statistics (Figures 20-22).

Model Selection

We used Stock Synthesis (Methot 1990, 1998, 2000) to model the dynamics of the black rockfish population inhabiting the coast off Oregon and California. The model is a forward-projecting, separable, age-structured population model. Key features of the model are (1) it incorporates a multinomial sampling error structure for age and length composition data, (2) log-normal errors for survey indices, (3) it explicitly models age reading error when constructing predicted age composition data, and (4) it conveniently allows a variety of data elements to be combined and evaluated under one umbrella formulation. In particular, all data types are combined in a total log$_e$-likelihood equation of the form:

$$\ell_{Total} = \sum_{i=1}^{m} \ell_i \cdot \lambda_i$$

where ℓ_{Total} is the total log$_e$-likelihood of the model and the ℓ_i are the individual log$_e$-likelihoods for each of the ***m*** data components used by the model. These are weighted by the "emphasis" factors (λ_i), such that in combination the various data sources used by the model can be controlled. To reduce the influence of one data type, the particular λ_i can be reduced to a nil emphasis (e.g., 0.0001). For this assessment, the length-based version of the Synthesis Model was used, which allows more effective use of length-frequency data. In particular, we used the most recent version of SYNL32R.EXE (compiled 4/2/2003, 1,239 KB). All modeling was conducted using a convergence criterion of 0.001 log-likelihood units.

A variety of model structures was explored prior to establishing a base stock assessment model. Initial efforts were simply to get the model to converge using all data elements, which included the following likelihood components (ℓ_i): (1) Oregon recreational landings, (2) Oregon recreational age compositions, (3) Oregon recreational length compositions, (4) Oregon recreational mean lengths-at-age, (5) Oregon hook-and-line landings, (6) Oregon hook-and-line length compositions, (7) Oregon trawl landings, (8) Oregon trawl length compositions, (9) California recreational landings, (10) California recreational length compositions, (11) California hook-and-line landings, (9) California hook-and-line length compositions, (10) California trawl landings, (11) California trawl length compositions, (12) RECFIN CPUE for the Oregon recreational fishery, (13) ODF&W CPUE for the Oregon recreational fishery, (14) RECFIN CPUE for the California recreational fishery, and (15) CDF&G CPUE for the California recreational fishery (Table 11).

All the first models we examined included dome-shaped selectivity patterns for the four recreational and hook-and-line fisheries, but logistic (i.e., asymptotic) selectivities for the two trawl fisheries, although selectivity in all six fisheries was modeled using selectivity option #7 in the length-based model, with pure length based selectivity and no selectivity differences between the two sexes (Methot 2000). Subsequently, an effort to implement logistic selectivity curves for the four recreational and hook-and-line fisheries was attempted and then discarded due to unacceptable deteriorations in the fit of the model to the data.

The spawner-recruit section of the Stock Synthesis parameter file was initially configured as a deterministic Beverton-Holt spawner-recruit curve with constant recruitment (steepness = 1.0). This was supported by early profiling on the steepness (***h***) parameter, which indicated that a model with ***h*** = 1.0 fit the data best. However, upon revisions to the model completed during the STAR review, re-profiling on the steepness parameter revealed a maximum in likelihood at ***h*** = 0.65, coinciding with the posterior mean steepness from Dorn's (2002) Bayesian hierarchical meta-analysis of rockfish productivity. Because of these considerations, the final version of the stock assessment model fixed steepness at a value of 0.65. In addition, rather than assuming a deterministic spawner-recruit curve, stochastic recruitment was incorporated by explicitly estimating year-specific recruitments of age-2 fish from 1975-98. This was feasible because age composition data were available for the Oregon recreational fishery from 1990-2001 (Table 4) and age 3-15 year old fish are reasonably well represented in the catch.

Consideration of the natural mortality rate (**M**) was also important in model development. Based on an initial attempt to estimate **M** with a catch curve analysis, the very first model runs fixed **M** for both sexes at 0.18 yr^{-1}. However, subsequent profiling on this parameter showed that 0.14 yr^{-1} provided a better fit to the data and, in addition, was more consistent with results from Hoenig (1983). He showed that total mortality could be estimated from information on longevity (i.e., maximum age), which in the case of black rockfish is about 35 yr (see Figure 2), which translates into an estimate of total mortality rate equal to 0.115 yr^{-1}. Moreover, there was clear evidence that the mortality rate of females was greater than males (see Figures 2 & 7). Consequently, the final version of the model was configured to have male and female natural mortality rates equal up until age 10, at which time the female natural mortality rate shifted abruptly to a new, higher value.

Another area that was explored at some length in the development of the base assessment model was time-varying selectivity. In particular, it became clear that there was a severe lack of fit to the California sport length-frequency data, with large + residuals (observed > predicted) evident prior to 1990 and large negative residuals prevailing after that year. Consequently, based preliminary results and upon the recommendation of the STAR panel, two selectivity curves were estimated for the California recreational fishery, one for the period 1945-89 and one for the period 1990-2002. Each period was allowed to have distinct parameter estimates for the inflection point of the ascending portion of the curve and the slope of the descending portion. Otherwise, the remaining five parameters associated with selectivity option #7 were identical in both time periods (note: all models assumed male selectivity was equal to female selectivity). Allowing for time variability in selectivity resulted in a great improvement in fit, however, it ascribed the dramatic decline in the size of black rockfish taken in the California sport fishery (Figure 15) to a lack of availability of large fish in recent years, rather than to the persistent and cumulative effects of substantial fishing. Importantly, this latter hypothesis could not be reconciled with the flat trajectories of all four CPUE indices.

Finally, the length-based version of the Stock Synthesis model is able to utilize estimates of mean length-at-age (Methot 2000), which were developed from the ODF&W recreational data. However, ultimately this source of information was de-emphasized (i.e., $\lambda = 0.1$) in the final version of the assessment model because it would, in essence, double-count the data and the information was in conflict with other model components (see emphasis profiling below).

Base Population Model

One of the more unique aspects of the Stock Synthesis Model is its ability to simulate measurement errors associated with ageing fish (Methot 1990, 2000). Observed data are assumed to be subject to ageing error, with strong year-classes smeared into adjacent weaker cohorts. To configure this aspect of the model, we used information on black rockfish summarized in Wallace and Tagart (1994), who reported that 45.9% of 4-year-olds were mis-aged by WDFW staff, and that 80.3% of fish older than 20 years were mis-aged. Using their data, we estimated about 60% agreement for 2-year-old fish and 10% agreement for 25-year-old black rockfish. These percent agreement values were fixed in all subsequent model runs.

The determination of appropriate sample sizes has been a recurring problem in composite maximum likelihood models, including Stock Synthesis. For example, catch and survey samples are typically taken as clusters of fish and a number of mechanisms can cause within-cluster variance to be severely reduced relative to an equivalent number of independently and identically distributed samples. However, an empirical estimate of the "effective" sample size ($\boldsymbol{N_{eff}}$) is provided by the Synthesis Model, based on the ratio of the variance of the expected proportion ($\boldsymbol{p}$) from a multinomial distribution to the mean squared error of the observed proportion ($\boldsymbol{p'}$), i.e.,

$$N_{eff} = \frac{\sum p(1-p)}{\sum (p-p')^2}$$

We treat $\boldsymbol{N_{eff}}$ as an imprecise measurement from which one can derive a general relationship between effective sample size and actual sample size (either in the number of fish examined or the number of clusters sampled) for each fishery. The general relationship between $\boldsymbol{N_{eff}}$ and actual sample size is given by a zero-intercept regression using the ratio estimator $\Sigma Y / \Sigma X$ for the slope, which is appropriate when the variance in Y is proportional to the magnitude of X. We then replaced each observed sample size with the corresponding effective sample size predicted by the regression, thus "smoothing" the estimates. When alternative regression estimates exist (e.g., based on the number of fish or the number of clusters), we used the mean of the alternative estimates. The effective sample sizes are generally much smaller than the actual numbers of fish examined (Figure 24), but still can be quite large in some years.

The final stock assessment model fixed the natural mortality rate (**M**) of females and males up to age 10 yr at a value of 0.12 yr^{-1} (see above). After that age the natural mortality rate of females increased to 0.20 yr^{-1}. This final configuration of the model was settled on after considering the longevity of black rockfish and the results of profiling the model over a wide range of **M** values (Figure 25), not all of which converged successfully.

The base model assumed deterministic Beverton-Holt recruitment for the years 1945-74 and 1999-2002, with steepness (***h***) equal to 0.65 (Table 12, Figure 26). In contrast, from 1975-98, year-specific stochastic recruitments ($\sigma = 0.4$) were estimated as deviations from the deterministic spawner-recruit relationship. Allowing stochastic recruitment during this latter time period increased the number of estimated parameters in the model by 24, but was accompanied by a 113.4 unit increase in total log-likelihood (4.7 units/parameter). This increase in goodness-of-fit was apparently due to an increasing trend in estimated recruitments during the 1975-98 period, which occurred at a time when spawning output was declining (see below). Because the Beverton-Holt spawner-recruit model is a monotonic increasing function, without recruitment stochasticity, the model could not generate increasing recruitment if spawning were decreasing. The data that were primarily responsible for this marked improvement in fit with the introduction of reproductive stochasticity were: (1) the Oregon recreational length compositions [+44.7 log-likelihood units; Figures 11 and 12], (2) the California hook-and-line length compositions [+23.0 log-likelihood units; Figure 16], and (3) the Oregon recreational age data [+21.7 log-likelihood units; Figure 8].

Given the time series of recruitments estimated by the model, in combination with the fishery catches and natural mortality rate, the total age 2+ biomass of the black rockfish stock is estimated to have declined from a high of 20,510 mt in 1945 to a low of 7,702 mt in 1986 (Table 12, Figure 27). Since 1986 the population has increased, due to the strong recruitments that occurred after 1985, especially the 1996 and 1997 recruitments, corresponding to the 1994 and 1995 year-classes. In 2002 the exploitable biomass was estimated to be 11,232 mt.

Because female black rockfish are 50% mature at a size of about 40 cm (Figure 4), which corresponds to an age of approximately 8 yr (Figure 2), there is a 6 year delay between recruitment at age 2 and when a cohort begins to contribute substantially to spawning output. This lag is apparent when the time series of spawning output is examined (Table 12, Figure 28). Results show that, because fishing was assumed to begin in 1945, spawning at that time was the same as an unexploited stock (i.e., B_0 = 3,144,660 spawning units = 100% spawning output). By 1987 it had reached a low point (28%), but then had increased to 49% of the unexploited level by 2002. Most of that increase was accomplished in the last 4 years. Given the level of spawning depletion in 2002, the black rockfish stock off Oregon and northern California is estimated to be above the management target level ($B_{40\%}$) and it has never fallen below the minimum stock size threshold ($B_{25\%}$).

Base model results presented in Figure 29 show time series of exploitation rate (catch divided by exploitable biomass) from 1975-2002 for each of the six fisheries considered. As expected, the two recreational fisheries (especially the Oregon fishery) have been responsible for the greatest fishing mortality on the stock. In recent years the exploitation rates of all 6 fisheries have declined noticeably. Likewise, the selectivity curves for each of the 6 fisheries are shown in Figure 30 (see also Table 13). In the figure it is apparent that the California recreational fishery removes black rockfish at a much smaller size than any of the other fisheries. For example, by 32 cm FL black rockfish are fully selected in that fishery, but haven't even begun to appear in the two trawl fisheries. Also, note the substantial difference in selection in the California sport fishery when the two time periods are compared (1945-89 and 1990-2002). Whereas large fish ($\geq$ 38 cm FL) were captured during the earlier time period, in more recent years fish of that size range were unavailable to the fishery. By allowing time-varying selectivity, the model ascribes the recent absence of large fish in the California sport fishery (see Figure 15) to a change in availability, as opposed to fishing down the stock. Note that the selectivity patterns of the California hook-and-line fishery and the Oregon recreational fishery are quite similar to one another and these are not that different from the Oregon hook-and-line fishery, which harvests slightly larger fish.

Results presented in Figures 31 and 32 depict the fit of the base stock assessment model to all of the compositional data, including: (1) sex-specific Oregon sport age compositions, (2) sex-specific Oregon sport length compositions (1990-2001), (3) combined-sex Oregon sport length compositions (1980-1989 and 2002), (4) the sex-specific Oregon hook-and-line length compositions, (5) combined-sex Oregon trawl length compositions, (6) combined-sex California sport length compositions, (6) combined-sex California hook-and-line length compositions, and (7) combined-sex California trawl length compositions (see also Table 11). In the figures standardized residuals ($\boldsymbol{r_s}$) as displayed as circles. These are defined as:

$$r_s = \frac{(p-\hat{p})}{\sqrt{\dfrac{\hat{p}\cdot(1-\hat{p})}{n}}}$$

where p is the observed proportion, $\hat{p}$ is the predicted proportion, and n is the sample size, i.e., the residual divided by the standard error of the estimated proportion. Note that the size of the circle is proportional to r_s, filled circles represent positive residuals, and open circles depict negative residuals. For ease of interpretation, all graphs are similarly scaled. Results show relatively good fit of the model to the California hook-and-line and the California sport length compositions, particularly after allowing the selectivity pattern of the latter fishery to vary over time. The Oregon sport age compositions show a pattern of large residuals (both positive and negative) for the youngest ages. In the figures one can easily observe regions in which the model was incapable of providing a good fit to the data and regions where it could.

The fit of the model to the four CPUE statistics is shown in Figure 33. Again, for ease of comparison, the abscissa of all four graphs is scaled identically. It is evident that the model fits the trend in these indices with a largely flat population trajectory and is unable to capture high-frequency variability in the observed indices. Note the abrupt decline in CPUE that occurred in the California RECFIN and CDF&G recreational statistics, which is due to the abrupt change in selectivity that occurred in 1990 that led to a decline in availability of large, old fish (see above).

The length-based version of the Stock Synthesis can be configured to allow fishery removals to be based only on the length of fish. This could lead to cumulative size-selective mortality effects on a single cohort as the larger, faster growing fish are removed relatively sooner than the smaller, slower growing fish of identical age. If this condition accurately represents reality, age-length samples obtained from fisheries would be biased towards large fish, particularly at young ages. One might infer, therefore, that the average fork length of 2-, 3-, and 4-year-old fish shown in Figure 2 is not representative of the population mean. Presented in Figure 34 is the initial, purely data-based estimated von Bertalanffy growth curves of male and female black rockfish and the final, stock assessment-based estimated growth curves. The latter growth curves represent the bias-corrected growth trajectories.

In order to evaluate the effect of de-emphasizing the Oregon recreational mean length-at-age data to the base assessment model (see section on Model Selection above) and, in particular, how other data components interacted with the length-at-age information, the base model was profiled by changing the emphasis level on the Oregon sport mean length-at-age data component. Results show (Figure 35) that as the emphasis on that particular component increased, the fit of the model to 6 of the remaining 7 data components was degraded. This finding supports de-emphasis of the mean length-at-age data in the final version of the model.

All modeling in this assessment used the latest version of the Stock Synthesis model (SYNL32R.EXE, 1,239 KB, dated 4/2/2003), which has improved convergence characteristics (R. Method, pers. comm.). Nonetheless, the final version of the model was probed by randomization of initial parameter values and re-running the model to see if it converged to the same "global" solution. Results show that it did (Figure 36). In particular, by the 10th iteration of the optimization procedure the ending summary biomass was with 10% of the final solution. Moreover, the model's total log-likelihood over all runs was remarkably consistent (-1,232.8).

In addition to evaluating the convergence properties of the base model, a retrospective analysis was also conducted, as suggested in the Pacific Fishery Management Council's Terms of Reference for Groundfish STAT Teams. Results show somewhat peculiar behavior of the model (Figure 37) as the terminal year of the model is successively truncated. Note the substantial jump in age 2+ biomass that occurs as the model is shortened to the point of ending in 1998. We interpret this as a result of the model estimating deterministic recruitments for the 1999-2002 period. Even so, the overall retrospective pattern is for the model to overestimate stock abundance, which is clearly an undesirable result.

Sources of Uncertainty

It is important to consider as many potential sources of error as possible when fitting complex nonlinear models to multiple sets of data, like we have attempted here. For example, one obvious source of uncertainty is the model's measurement error, that is the residual variance remaining after a particular model has been fit to specific data. In that regard the Monte Carlo-Markov Chain (MCMC) method is a good way of characterizing the marginal distribution of derived quantities from the model (e.g., terminal year spawning depletion). However, the Stock Synthesis model does not currently have an option for doing MCMC calculations, although that capability is being developed and will be implemented as a feature within the model. Even so, a much simpler estimate of measurement error is provided by the program that is based on the so-called Delta-Method, which uses numerical derivatives, the parameter variance-covariance matrix, and the first few terms of a Taylor series expansion as an approximation to the quantity in question. In this instance, the approximate coefficient of variation for the terminal year spawning output of black rockfish, based on the Delta-Method approach, is 5.7%, which provides a rough sense of the residual variability in the assessment. Thus, we might expect that quantity to be estimated with an accuracy of about ± 10-15%.

There are other important sources of uncertainty, however, that are unaccounted for in the model's residual variance. One is model specification error, which represents the error that occurs when an inappropriate model is used to represent reality. Of course the analyst seldom knows for certain what the "correct" model is but, instead, engages in a process of model selection and evaluation, using goodness-of-fit measures and other diagnostics, until the key characteristics of the data are captured by the model (Hilborn and Mangel 1997). We previously described the development of the black rockfish stock assessment model (see Model Selection) and, following the arguments presented in that section, we assume that model specification error can be considered minimal. Nonetheless, there still remains a potentially important source of error in the assessment that is attributable to errors in the data and/or to fixed parameters, which essentially behave like data. In particular, for the black rockfish model two items merit increased scrutiny to evaluate the sensitivity of the final results to errors in their specification. These are: (1) the spawner-recruit steepness parameter and (2) the level of historical catch prior to 1978.

In this assessment we modeled the black rockfish spawner-recruit relationship using the Mace and Doonan (1988) formulation of the Beverton-Holt curve. The key parameter of that curve, which governs the overall resilience and productivity of the stock, is the steepness parameter (***h***). In our base model we fixed ***h*** = 0.65, primarily based on Dorn's (2002) Bayesian hierarchical meta-analysis of *Sebastes* productivity. That study showed that a value of 0.65 is a good point estimate for west coast rockfish stocks. However, there is considerable variability in steepness within the genus and some species (bocaccio, canary, and widow rockfish) show virtually no compensatory response (steepness ≈0.2). In addition to Dorn's (2002) meta-analysis, a preliminary likelihood profile over steepness values ranging from 0.50–1.00, obtained from the penultimate version of the black rockfish model that preceded final changes in natural mortality rates, indicated that the best fit of the model occurred at ***h*** = 0.65 (Figure 38). Following changes to the mortality schedule, however (see Figure 25), a subsequent profile on steepness (solid line in Figure 38) showed a marginally better fit at a steepness value of 0.50, corresponding to a small improvement of 0.70 units of log-likelihood. While such a minor change in likelihood is, in isolation, largely inconsequential, it is worth noting that spawning depletion in the base model drops from 48.8% to 42.5% as steepness goes from 0.65 to 0.50, i.e., stock status is quite sensitive to this poorly estimated parameter. Because ***h*** is fixed in the assessment, we urge caution in using the model due to this significant source of uncertainty.

Also shown in Figure 38 are changes in log-likelihood specific to certain data elements within the model. Only those components whose fit was clearly affected by altering the steepness parameter are presented in the figure. It is intriguing that increasing steepness degrades fits to Oregon recreational length compositions, but improves fits to the Oregon recreational age compositions. Similarly, model fits to the California trawl length composition data and the California hook-and-line length composition are oppositely affected by the steepness parameter. We have no explanation for these patterns.

During the review of the black rockfish assessment a fair amount of discussion was devoted to establishing the historic level of catch prior to 1978 (see **Historical Catch** above). Initially, there was considerable discomfort among members of the panel with starting the model in 1978, while simultaneously specifying a substantial level of historical catch. That concern led to the reconstruction of a black rockfish catch history dating back to 1945, when catches were *de facto* assumed to be zero. However, the panel was still concerned that the reconstruction was highly uncertain and could have a major influence on the conclusions of the stock assessment. Consequently, the STAR panel requested an analysis to assess the affect of uncertainty vis-à-vis the time series of historical catch. In so doing, the panel specified high and low levels to bracket a plausible range of historical catches (Figure 39). Note that under the base model the 1945-77 cumulative black rockfish catch from all fisheries from was 17,100 mt. To bracket that value a hypothetical high catch stream was constructed, which would have resulted in 26,100 mt of catch. Similarly, the supposed low catch stream would produce a cumulative catch of 9,400 mt.

Next, the base model formulation was re-fitted to separate data sets constructed with the high and low catch streams and the result fits were compared with the base model (Figure 40). Note that under the high catch scenario, virgin recruitment (i.e., recruitment in 1945) and all deterministic recruitments were relatively high, whereas the low catch scenario produced the lowest recruitments. During the period 1975-98, when year-specific stochastic recruitments were estimated, the three models showed little difference. Plots of the spawning depletion ratio for each of the three models (lower panel) showed that the "high catch" population underwent a more rapid depletion, as would be expected. However, by the ending year of the model (2002) the three representations of catch produced similar depletion ratios, that only ranged from 45% (high catch) to 51% (low catch). Thus, the increased recruitment/production that characterized the high catch population model was nearly sufficient to compensate for the much greater removals.

Yield Projections

The base model estimated that the spawning depletion ratio of black rockfish in 2002 was 48.8% (Table 12), putting it well above the PFMC's precautionary threshold of 40% of unfished spawning output. Hence the default harvest policy for *Sebastes* spp. is to harvest at an $F_{50\%}$ rate with no 40:10 precautionary reduction in OY. That is the rate of fishing mortality that reduces the spawning potential per recruit to half of that expected in the absence of fishing (Figure 41). In this instance an $F_{50\%}$ rate is equivalent to an exploitation rate of ~7.7%.

The Stock Synthesis program was used to project the base population model forward for ten years under an $F_{50\%}$ harvest regime, with catch allocation among the six fisheries based on the last three years of landings (2000-2002) and deterministic recruitments drawn from the spawner-recruit curve. In addition, comparable projections were developed for the high and low catch scenarios discussed previously. Results show (Table 14, Figure 42) that over the next 10 years the allowable biological catch (ABC) is forecast to decline from 802 mt in 2003 to 708 mt in 2012, as the elevated recruitments of 1994-1997 pass through the population (see Figure 26). For comparison, the high historical catch scenario would be expected to produce greater ABCs (i.e., 886-816 mt from 2003-2012) but to be at a lower depletion level than the base model, consistent with the discussion above. Likewise, the low catch scenario results in lower ABCs (757-654 mt) with the stock at a relatively higher level of abundance. After 10 years of harvesting at $F_{50\%}$ all three models predict that the depletion ratio will remain above the 40% precautionary threshold. Similarly, the lowest forecasted ABC, among all year and model combinations, is 654 mt. That quantity is about equal to the annual average of recent landings (2000-2002). Using projections from the base model, there is some room for catches in the next few years to increase, although given the projected trend in biomass (down), and uncertainty in historical catches and the spawner-recruit steepness (see above), a *status quo* total harvest would be a robust alternative.

In order to characterize a key source of uncertainty in the stock assessment the STAR panel chose to highlight the importance of the 1945-77 time series of historical catches. To demonstrate the conservation repercussions that could arise if the stock were managed based on an assumed 1945-77 catch stream (i.e., the base model), when in fact historical catches were something different (i.e., high & low catch scenarios), we constructed a decision table (Table 15). Note that in the upper portion of the table, under the heading labeled “True” State of Nature, the columns represent three alternative views of reality, with their associated ABCs. Thus, if actual catches from 1945-77 were equivalent to the high scenario, the appropriate five-year average ABC (2003-2007) would be 847 mt, and so on. The lower portion of the table shows what happens to the “True” stock if removals are based on an assumed state of nature (i.e., high, medium, or low ABCs). Clearly if the true state is “low catch history” and the assigned ABC is 711 mt, the appropriate management action is taken. Thus, the diagonal of the table represents no management error. Off-diagonal elements, however, represent situations where the wrong ABC is taken from the stock (either too high or too low).

To gauge the conservation impact of errors in management due to mis-specifying ABC, we calculated the total spawning depletion of the stock after five years of removals. Thus, the base model predicts that the stock will be reduced to 50.0% of virgin spawning output after five years of harvesting with an average ABC of 758 mt (see also Table 14). Similarly, “correct” management under the low and high catch scenarios is expected to result in spawning depletion ratios of 51.7% and 47.1%, respectively. Note that, with respect to stock conservation, the worst type of error is assuming a high catch scenario (ABC = 847 mt) when in fact the true state of nature was a low catch scenario (least stock production). In that instance, the depletion ratio after 5 years of harvest is 48.3%, which is down from 51.7% when properly managed. In no case within the decision table does depletion fall below, or even approach, the precautionary threshold (40%). We conclude from this analysis that management errors in setting ABC based on having to chose among alternative levels of historic catch are of relatively minor consequence to black rockfish stock conservation.

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Table 1. Regulatory history for west coast black rockfish south of the Columbia River.

Date	Regulatory Action
1/83	40,000 lb trip limit *Sebastes* complex coastwide; recreational: California and Oregon 15 fish per angler
1/84	30,000 lb trip limit for *Sebastes* complex north of Cape Blanco with a 1 trip per week restriction, no change south
5/84	15,000 lb trip limit for *Sebastes* complex once per week north of Cape Blanco
8/84	7,500 lb/trip once per week or 15,000 lb/trip once per 2 weeks for *Sebastes* complex north of Cape Blanco
1/85	30,000 lb weekly trip limit for *Sebastes* complex north of Cape Blanco, no change south
4/85	15,000 lbs per weekly trip or 30,000 lbs per biweekly trip north of Cape Blanco
10/85	20,000 lbs per weekly trip or 40,000 lbs per biweekly trip north of Cape Blanco for *Sebastes* complex
1/86	25,000 lbs per weekly trip or 50,000 lbs per biweekly trip for *Sebastes* complex north of Cape Blanco, no change south
9/86	30,000 lbs per weekly trip or 60,000 lbs per biweekly trip north of Cape Blanco for *Sebastes* complex
1/87	25,000 lbs per weekly trip or 50,000 lbs per biweekly trip north of Cape Blanco for *Sebastes* complex, no change south
1/88	No change for *Sebastes* complex
1/89	No change for *Sebastes* complex
1/90	No change for *Sebastes* complex
1/91	25,000 lbs per trip south of Cape Blanco for *Sebastes* complex, no change north
1/92	50,000 lbs cumulative *Sebastes* complex per 2 weeks coastwide
1/93	No change for *Sebastes* complex
1/94	Limited entry: 80,000 lbs cumulative *Sebastes* complex per month month coastwide open access: 10,000 lbs per trip not to exceed 40,000 lbs per month coastwide recreational: **10 black rockfish in 15 rockfish bag per angler for Oregon**
9/94	Limited entry south of Cape Mendocino raised to 100,000 lbs cumulative per month
1/95	Limited entry: 35,000 lbs cumulative *Sebastes* complex north of Cape Lookout; 50,000 lbs cumulative per month between Cape Lookout; 100,000 lbs cumulative per month south of Cape Mendocino; open access fixed gear: 35,000 lbs cumulative north of Cape Lookout for fixed gear (except pot and hook and line); 40,000 lbs per cumulative month south of Cape Lookout; 10,000 lbs per trip for pot and hook and line coastwide
1/96	Limited entry: 70,000 per 2 months north of Cape Lookout; 100,000 lbs per 2 month between Cape Lookout and Cape Mendocino; 200,000 lbs per 2 month period south of Cape Mendocino; open access fixed gear except hook and line and pot: 35,000 lbs per month north of Cape Lookout; 40,000 lbs per month south of Cape Lookout open access fixed hook and line and pot: 10,000 lbs/trip open access trawl: not to exceed 50% of limited entry
1/97	Limited entry: 30,000 lbs per 2 month period north of Cape Mendocino; 150,000 lbs per 2 month period south of Cape Mendocino; open access trawl not to exceed 50% of this open access; fixed gear: 40,000 lbs per month coastwide with a 10,000 lb trip limit for hook and line and pot
1/98	Limited entry: 40,000 lbs per 2 months north of Cape Mendocino; 150,000 lbs per 2 months south of Cape Mendocino open access, fixed gear: no change open access, trawl: no change
7/98	Limited entry: south of Cape Mendocino reduced to 40,000 lbs per two months
10/98	Limited entry: monthly trip limit reduced to 15,000 lbs open access: no landings north of Cape Blanco
1/99	Limited entry managed by a complex 3 phase landing system, Open access: North of Cape Mendocino - 3,600 lbs/month; 2,000 lbs per month south of Cape Mendocino
4/99	Open Access: North of Cape Mendocino - 12,000 lbs per month with no more than 3,500 lbs per month being blue and black rockfish
5/99	Limited Entry: North of Cape Mendocino - 2 month cumulative limit of 30,000 lbs of *Sebastes* complex through Sep; South of Cape Mendocino - 2 month cumulative limit of 3,500 lbs of *Sebastes* complex
8/99	Limited entry north of Cape Mendocino: 10,000 lbs cumulative bimonthly limit for all *Sebastes* other than canary and yellowtail rockfish
1/00	Black rockfish managed as a minor nearshore species, Limited Entry Trawl: 200 lbs per month of minor nearshore species coastwide, Limited Entry Fixed Gear: 2,400 lbs coatwide limit for minor nearshore of which no more than 1,200 lbs may be species other than blue or black rockfish, Open Access: North - 1,000 lbs/2 months of minor nearshore rockfish of which no more than 500 lbs may be other than blue or black rockfish, South - 550 lbs/2 months with a 2 month closure (variable by location), Recreational: 2 month closures (variable by location) south of Cape Mendocino, bag limit 10 fish per day, Oregon bag limit of 10 fish per day.

Table 1 (cont.).

Date	Regulatory Action
5/00	Limited entry non-trawl limit: north of Cape Mendocino -cumulative bimonthly limit of nearshore rockfish increased to 3,000 lbs of which no more than 1,400 lbs may be other than blue or black rockfish; south of Cape Mendocino - 1,300 lbs per 2 months of minor nearshore rockfish, Open Access, Non trawl fishery: 1,500 lbs minor nearshore rockfish per two months of which no more than 700 lbs may be species other than blue or black rockfish. Special: from May-Sep 2,200 lbs of minor nearshore rockfish per month for Pacific City (Oregon) of which no more than 700 lbs may be other than blue or black rockfish; landings of minor nearshore rockfish at Pacific City prohibited after September
7/00	Limited entry, fixed gear: North of Cape Mendocino - 5,000 lbs of minor nearshore rockfish per 2 month period with a maximum of 1,800 lbs of species other than blue or black rockfish; south of Cape Mendocino - 2,000 lbs of minor nearshore species per 2 month period, Open Access: North of Cape Mendocino - 3,000 lbs of minor nearshore rockfish with no more than 900 lbs of species other than blue or black rockfish; South of Cape Mendocino - 1,600 lbs per 2 month period of minor nearshore rockfish
10/00	Limited entry, fixed gear: North of Cape Mendocino - 10,000 lbs cumulative bimonthly for minor nearshore rockfish with no more than 2,000 lbs of non blue or black rockfish; south of Cape Mendocino - 6,000 lbs of minor nearshore rockfish per two month trip; South of Pt Conception - 9,000 lbs /2 months for October and 3,000 lbs per two month period for November and December; Open Access: North - 6,000 lbs of minor nearshore rockfish per 2 months with no more than 2,000 lbs other than blue or black rockfish; South - 4,000 lbs of minor nearshore rockfish per 2 month period
1/01	Limited entry trawl: 200 lbs/month of minor nearshore rockfish coastwide limited entry fixed gear: North - 10,000 lbs per 2 months of minor nearshore rockfish of which no more than 4,000 lbs may be other than blue or black rockfish; South (Monterey INPFC area) - 2,000 lbs per 2 months during Jan-Feb and July-Dec, closed Mar-April, closed outside of 20 fathoms May-June; open access: North - 3,000 lbs per 2 month period of which no more than 900 lbs may be other than blue or black rockfish; Monterey INPFC area - 1,800 lbs per 2 months during Jan-Feb and July-Dec, closed Mar-April, closed outside of 20 fathoms May-June; recreational: California - Closed March-April, In the Monterey INPFC area closed May-June except for inside the 20 fathom line
5/01	Limited entry in north: 7,000 lbs per 2 month period through December of which no more than 4,000 lbs may be other than blue or black rockfish open access in north: 7,000 lbs per 2 month period through December of which no more than 900 lbs may be other than blue or black rockfish
1/02	Limited entry trawl: North - minor nearshore rockfish closed Sep-Oct, otherwise 300 lbs/month; South 500 lbs per month minor nearshore rockfish Jan-April, 1,000 lbs/month May-June, then closed Limited entry fixed gear: North - 5,000 lbs/month of minor nearshore rockfish no more than 2,000 lbs of which may be other than blue or black rockfish through April, reducing to 7,000 lbs per 2 months by year end; South (Monterey INPFC area) - 1,600 lbs per 2 months Jan-Feb, closed Mar-Apr, then 1,600 lbs per 2 months inside of 20 fathoms May-Aug, then closed; Open access: North - 3,000 lbs per 2 months of minor nearshore rockfish through April (no more than 1,200 lbs of which may be other than blue or black rockfish), increasing to 7,000 lbs per 2 months by year end (no more than 3,000 lbs of which may be other than blue or black rockfish); South (Monterey INPFC area) - 1,200 lbs of minor nearshore rockfish Jan-Feb, closed Mar-April, 1,200 lbs inshore of 20 fathoms through September, then closed; recreational: California - North of Cape Mendocino open year round, Monterey INPFC are is closed March - April and Nov-Dec and outside of 20 fathoms it is closed May - Oct
1/03	Limited Entry trawl: 300 lbs per month costwide limited entry fixed gear: North - 3,000 lbs per 2 months of minor nearshore rockfish of which no more than 900 lbs may be other than blue or black rockfish; South - All fishing inside of 20 fathoms or outside of 150 fathoms, 200 lbs per 2 months minor nearshore rockfish Jan-Feb and Nov-Dec, closed Mar-April, 400 lbs per 2 months May - June and Sep-Oct, 500 lbs per 2 months July-Aug; Open Access: Same as limited entry; Recreational: California (Monterey INPFC) - inside of 20 fathoms, closed Jan-June; No change for Oregon or northern California

Table 2. Sex-specific von Bertalanffy growth parameter estimates for black rockfish from Oregon and California. The Schnute (1981) parametization was employed in fitting the data, with τ_1 = 5.0 yr and τ_2 = 15.0 yr. Initial values of parameters were obtained by fitting the growth model external to the stock assessment model. Other than the four coefficients of variation (CVs), final values were estimated within the model.

Sex	Parameter	Initial Value	Final Value
female	K [yr^{-1}]	0.1495	0.2022
	FL [cm] @ age 5	34.83	32.21
	FL [cm] @ age 15	46.34	47.95
	CV FL @ age 5	8.79%	8.79%
	CV FL @ age 15	8.82%	8.82%
male	K [yr^{-1}]	0.1384	0.1979
	FL [cm] @ age 5	34.56	31.88
	FL [cm] @ age 15	43.85	45.39
	CV FL @ age 5	8.24%	8.24%
	CV FL @ age 15	6.45%	6.45%

Table 3. Black rockfish landings [mt] from the sport (i.e., recreational), hook-and-line, and trawl fisheries from 1945-2002 in Oregon and northern California.

	Oregon			California			
Year	Sport	Hook	Trawl	Sport	Hook	Trawl	Total
1945	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1946	11.1	2.2	0.7	3.9	0.2	21.3	39.4
1947	22.1	4.4	1.5	7.8	0.4	42.6	78.8
1948	33.2	6.6	2.2	11.6	0.7	63.8	118.1
1949	44.2	8.8	2.9	15.5	0.9	85.1	157.4
1950	55.3	10.9	3.7	19.4	1.1	106.4	196.8
1951	66.4	13.1	4.4	23.3	1.3	127.7	236.2
1952	77.4	15.3	5.1	27.2	1.5	149.0	275.5
1953	88.5	17.5	5.9	31.0	1.8	170.3	315.0
1954	99.5	19.7	6.6	34.9	2.0	191.5	354.2
1955	110.6	21.9	7.3	38.8	2.2	196.9	377.7
1956	121.7	24.1	8.1	40.0	2.4	230.6	426.9
1957	132.7	26.3	8.8	41.2	2.7	250.1	461.8
1958	143.8	28.4	9.5	42.5	2.9	253.6	480.7
1959	154.8	30.6	10.3	43.7	3.1	216.4	458.9
1960	165.9	32.8	11.0	44.9	3.3	209.3	467.2
1961	177.0	35.0	11.7	45.4	3.5	157.8	430.4
1962	188.0	37.2	12.5	45.9	3.8	138.3	425.7
1963	199.1	39.4	13.2	46.4	4.0	173.8	475.9
1964	210.2	41.6	5.6	46.8	4.2	150.6	459.0
1965	221.2	43.8	75.1	47.3	4.4	127.4	519.2
1966	232.3	45.9	129.3	72.0	4.6	104.2	588.3
1967	243.3	48.1	162.6	96.7	4.9	81.0	636.6
1968	254.4	50.3	84.8	121.3	5.1	57.7	573.6
1969	265.5	52.5	181.4	146.0	5.3	34.5	685.2
1970	276.5	54.7	210.6	170.7	5.5	57.3	775.3
1971	287.6	56.9	93.2	195.3	5.8	55.3	694.1
1972	298.6	59.1	80.6	220.0	6.0	78.2	742.5
1973	309.7	61.3	33.4	244.7	6.2	108.0	763.3
1974	320.8	63.4	52.1	269.3	6.4	119.0	831.0
1975	331.8	65.6	108.4	294.0	6.6	130.0	936.4
1976	342.9	67.8	241.3	318.7	6.9	141.0	1118.6
1977	353.9	70.0	10.4	343.3	7.1	152.1	936.8
1978	365.0	72.2	66.6	368.0	7.3	163.1	1042.2
1979	373.6	72.2	223.1	368.0	2.8	59.6	1099.3
1980	270.4	72.2	45.2	285.0	1.8	59.5	734.1
1981	451.1	72.2	343.1	500.0	19.6	449.8	1835.8
1982	649.0	55.2	106.2	467.0	123.4	235.2	1636.0
1983	418.9	125.9	374.4	220.0	87.2	99.1	1325.5
1984	566.2	81.0	177.3	400.0	10.2	38.0	1272.7
1985	294.2	66.5	55.7	442.0	245.8	82.3	1186.5
1986	279.3	44.5	73.6	398.0	8.2	12.2	815.8
1987	280.6	69.4	17.0	212.0	9.8	75.0	663.8
1988	367.2	62.3	130.1	283.0	23.7	49.6	915.9
1989	486.0	72.8	101.7	230.0	101.3	25.7	1017.5
1990	402.0	97.5	23.9	243.5	128.1	0.5	895.5
1991	201.7	107.0	1.4	257.0	123.1	21.1	711.3
1992	360.3	302.2	10.5	270.5	200.4	50.3	1194.2
1993	360.8	65.7	43.7	284.0	129.1	2.2	885.5
1994	330.0	131.2	43.4	210.0	130.9	1.1	846.6
1995	377.4	158.5	4.3	158.0	156.9	2.7	857.8
1996	401.3	225.6	7.7	154.0	103.4	10.5	902.5
1997	375.9	267.6	17.1	91.0	112.8	14.1	878.5
1998	375.2	191.6	58.6	117.0	78.6	6.3	827.3
1999	301.6	207.7	2.3	162.0	49.0	3.9	726.5
2000	320.7	105.6	0.6	129.0	43.7	2.3	601.9
2001	275.4	146.2	0.2	248.0	96.6	2.1	768.5
2002	241.6	125.2	1.2	179.7	67.0	2.0	616.7

Table 4. Sex-specific age compositions for black rockfish taken in the Oregon recreational fishery (1990-2001).

		Age [yr]																						
Year	sex	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25+
1990	female	0.0000	0.0081	0.0105	0.0763	0.1211	0.0672	0.0591	0.0391	0.0424	0.0386	0.0324	0.0095	0.0086	0.0057	0.0057	0.0019	0.0014	0.0005	0.0010	0.0000	0.0000	0.0000	0.0000	0.0000
1990	male	0.0000	0.0062	0.0138	0.0663	0.0911	0.0482	0.0520	0.0329	0.0296	0.0296	0.0215	0.0205	0.0119	0.0100	0.0072	0.0052	0.0029	0.0067	0.0033	0.0024	0.0019	0.0014	0.0024	0.0038
1991	female	0.0010	0.0029	0.0240	0.0692	0.1212	0.1250	0.0529	0.0471	0.0346	0.0183	0.0106	0.0115	0.0010	0.0010	0.0019	0.0010	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1991	male	0.0000	0.0058	0.0125	0.0510	0.1125	0.0952	0.0442	0.0375	0.0288	0.0279	0.0212	0.0096	0.0058	0.0087	0.0038	0.0010	0.0010	0.0029	0.0010	0.0010	0.0029	0.0000	0.0000	0.0029
1992	female	0.0088	0.0246	0.0613	0.1094	0.0957	0.0870	0.0574	0.0142	0.0120	0.0098	0.0077	0.0049	0.0022	0.0016	0.0005	0.0005	0.0005	0.0005	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1992	male	0.0027	0.0284	0.0487	0.0832	0.0804	0.0957	0.0481	0.0274	0.0235	0.0126	0.0109	0.0120	0.0088	0.0055	0.0038	0.0011	0.0044	0.0000	0.0000	0.0000	0.0005	0.0000	0.0000	0.0033
1993	female	0.0023	0.0376	0.0660	0.0859	0.0959	0.0859	0.0475	0.0253	0.0092	0.0061	0.0115	0.0046	0.0008	0.0023	0.0008	0.0008	0.0000	0.0000	0.0000	0.0000	0.0008	0.0008	0.0000	0.0000
1993	male	0.0008	0.0460	0.0790	0.0744	0.0874	0.0621	0.0460	0.0291	0.0238	0.0138	0.0184	0.0107	0.0069	0.0069	0.0023	0.0015	0.0031	0.0008	0.0023	0.0000	0.0000	0.0000	0.0000	0.0008
1994	female	0.0000	0.0035	0.0605	0.0953	0.1134	0.0779	0.0452	0.0424	0.0299	0.0083	0.0049	0.0007	0.0035	0.0042	0.0042	0.0028	0.0014	0.0007	0.0014	0.0000	0.0000	0.0000	0.0000	0.0014
1994	male	0.0000	0.0063	0.0396	0.0974	0.0904	0.0605	0.0487	0.0466	0.0396	0.0146	0.0111	0.0090	0.0076	0.0083	0.0070	0.0014	0.0028	0.0007	0.0014	0.0028	0.0007	0.0000	0.0014	0.0007
1995	female	0.0010	0.0108	0.0424	0.0945	0.1054	0.0795	0.0532	0.0372	0.0258	0.0088	0.0062	0.0031	0.0021	0.0041	0.0021	0.0010	0.0021	0.0005	0.0005	0.0000	0.0005	0.0000	0.0000	0.0000
1995	male	0.0005	0.0062	0.0356	0.0961	0.1064	0.0764	0.0501	0.0367	0.0305	0.0196	0.0124	0.0119	0.0067	0.0088	0.0057	0.0036	0.0021	0.0041	0.0000	0.0005	0.0000	0.0005	0.0005	0.0041
1996	female	0.0024	0.0207	0.0520	0.0804	0.0928	0.0763	0.0426	0.0331	0.0177	0.0142	0.0112	0.0024	0.0018	0.0030	0.0012	0.0012	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1996	male	0.0024	0.0166	0.0509	0.1041	0.1041	0.0692	0.0585	0.0396	0.0195	0.0183	0.0130	0.0136	0.0089	0.0065	0.0047	0.0012	0.0059	0.0030	0.0030	0.0000	0.0024	0.0012	0.0000	0.0006
1997	female	0.0022	0.0234	0.0592	0.1206	0.0923	0.0891	0.0435	0.0369	0.0168	0.0114	0.0054	0.0049	0.0022	0.0011	0.0011	0.0000	0.0005	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1997	male	0.0005	0.0141	0.0435	0.0777	0.1010	0.0798	0.0521	0.0348	0.0255	0.0223	0.0120	0.0060	0.0054	0.0033	0.0027	0.0022	0.0011	0.0000	0.0005	0.0027	0.0000	0.0011	0.0000	0.0011
1998	female	0.0000	0.0118	0.0439	0.0705	0.0848	0.0817	0.0594	0.0390	0.0316	0.0173	0.0124	0.0105	0.0074	0.0062	0.0031	0.0019	0.0019	0.0000	0.0000	0.0006	0.0006	0.0000	0.0000	0.0006
1998	male	0.0000	0.0087	0.0248	0.0675	0.0897	0.0829	0.0514	0.0501	0.0359	0.0167	0.0235	0.0111	0.0087	0.0074	0.0074	0.0062	0.0043	0.0012	0.0019	0.0037	0.0025	0.0019	0.0025	0.0050
1999	female	0.0000	0.0050	0.0380	0.1064	0.1092	0.0869	0.0670	0.0363	0.0254	0.0078	0.0061	0.0036	0.0036	0.0011	0.0008	0.0006	0.0003	0.0000	0.0003	0.0003	0.0000	0.0003	0.0000	0.0006
1999	male	0.0003	0.0053	0.0338	0.1036	0.0930	0.0810	0.0665	0.0416	0.0218	0.0142	0.0087	0.0084	0.0061	0.0036	0.0028	0.0028	0.0017	0.0008	0.0014	0.0006	0.0008	0.0003	0.0003	0.0008
2000	female	0.0000	0.0062	0.0234	0.0827	0.1124	0.0808	0.0609	0.0452	0.0282	0.0145	0.0097	0.0056	0.0037	0.0023	0.0008	0.0012	0.0006	0.0000	0.0002	0.0000	0.0002	0.0002	0.0002	0.0000
2000	male	0.0006	0.0062	0.0280	0.0929	0.1177	0.0755	0.0551	0.0442	0.0299	0.0176	0.0126	0.0075	0.0070	0.0070	0.0073	0.0033	0.0021	0.0012	0.0008	0.0012	0.0012	0.0004	0.0004	0.0008
2001	female	0.0013	0.0010	0.0114	0.0344	0.0905	0.1203	0.0782	0.0701	0.0487	0.0214	0.0211	0.0071	0.0052	0.0039	0.0026	0.0013	0.0010	0.0026	0.0006	0.0003	0.0013	0.0003	0.0003	0.0016
2001	male	0.0003	0.0039	0.0117	0.0311	0.0834	0.1096	0.0590	0.0542	0.0363	0.0234	0.0156	0.0071	0.0075	0.0062	0.0065	0.0058	0.0026	0.0016	0.0016	0.0010	0.0006	0.0010	0.0000	0.0036

Table 5. Length compositions for black rockfish taken in the Oregon recreational fishery (1980-2002).

		Fork Length [cm]																				
Year	sex	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60
1980	combined	0.0011	0.0043	0.0106	0.0223	0.0723	0.0648	0.0871	0.0903	0.1073	0.1063	0.0903	0.1158	0.0712	0.0659	0.0499	0.0255	0.0117	0.0032	0.0000	0.0000	0.0000
1981	combined	0.0018	0.0054	0.0072	0.0181	0.0578	0.0632	0.1065	0.1336	0.1047	0.0884	0.1011	0.0866	0.0884	0.0596	0.0397	0.0235	0.0090	0.0018	0.0036	0.0000	0.0000
1982	combined	0.0000	0.0010	0.0040	0.0109	0.0169	0.0526	0.0745	0.1033	0.1360	0.1241	0.1351	0.1221	0.0963	0.0596	0.0348	0.0179	0.0079	0.0020	0.0010	0.0000	0.0000
1983	combined	0.0083	0.0055	0.0083	0.0249	0.0665	0.0803	0.0831	0.1025	0.1330	0.1080	0.1163	0.0831	0.0859	0.0582	0.0139	0.0166	0.0000	0.0000	0.0055	0.0000	0.0000
1984	combined	0.0000	0.0034	0.0075	0.0103	0.0274	0.0459	0.0623	0.1082	0.1466	0.1452	0.1404	0.1123	0.0767	0.0596	0.0336	0.0089	0.0089	0.0027	0.0000	0.0000	0.0000
1985	combined	0.0016	0.0090	0.0485	0.0411	0.0364	0.0501	0.0685	0.1033	0.1107	0.1450	0.1497	0.0996	0.0585	0.0416	0.0179	0.0105	0.0021	0.0037	0.0005	0.0016	0.0000
1986	combined	0.0021	0.0049	0.0246	0.0323	0.0400	0.0421	0.0779	0.0885	0.1419	0.1461	0.1685	0.1053	0.0660	0.0386	0.0084	0.0084	0.0035	0.0000	0.0007	0.0000	0.0000
1987	combined	0.0039	0.0147	0.0275	0.0451	0.0658	0.0756	0.1001	0.0736	0.1217	0.1089	0.1148	0.1021	0.0618	0.0393	0.0255	0.0137	0.0029	0.0020	0.0000	0.0010	0.0000
1988	combined	0.0069	0.0107	0.0214	0.0289	0.0572	0.0722	0.0955	0.1394	0.1099	0.1401	0.1175	0.0854	0.0484	0.0289	0.0251	0.0088	0.0038	0.0000	0.0000	0.0000	0.0000
1989	combined	0.0018	0.0009	0.0136	0.0145	0.0254	0.0481	0.0763	0.1272	0.1353	0.1199	0.1544	0.1090	0.0708	0.0545	0.0254	0.0064	0.0045	0.0045	0.0036	0.0018	0.0018
1990	female	0.0000	0.0000	0.0000	0.0023	0.0015	0.0058	0.0098	0.0283	0.0575	0.0848	0.0820	0.0851	0.0666	0.0505	0.0328	0.0149	0.0053	0.0020	0.0005	0.0000	0.0000
1990	male	0.0000	0.0000	0.0000	0.0020	0.0013	0.0052	0.0087	0.0251	0.0511	0.0753	0.0728	0.0755	0.0591	0.0448	0.0291	0.0132	0.0047	0.0018	0.0004	0.0000	0.0000
1991	female	0.0000	0.0000	0.0000	0.0008	0.0029	0.0058	0.0162	0.0249	0.0460	0.0971	0.1107	0.0888	0.0556	0.0411	0.0232	0.0079	0.0050	0.0008	0.0000	0.0000	0.0000
1991	male	0.0000	0.0000	0.0000	0.0007	0.0026	0.0052	0.0145	0.0224	0.0414	0.0872	0.0995	0.0797	0.0499	0.0369	0.0209	0.0071	0.0045	0.0007	0.0000	0.0000	0.0000
1992	female	0.0000	0.0000	0.0003	0.0034	0.0029	0.0115	0.0230	0.0364	0.0578	0.0934	0.0893	0.0848	0.0484	0.0291	0.0099	0.0042	0.0010	0.0000	0.0003	0.0000	0.0000
1992	male	0.0000	0.0000	0.0003	0.0035	0.0029	0.0117	0.0234	0.0370	0.0588	0.0950	0.0908	0.0863	0.0493	0.0296	0.0101	0.0043	0.0011	0.0000	0.0003	0.0000	0.0000
1993	female	0.0001	0.0009	0.0010	0.0051	0.0104	0.0194	0.0293	0.0446	0.0648	0.0841	0.0769	0.0669	0.0429	0.0218	0.0108	0.0027	0.0006	0.0010	0.0003	0.0000	0.0001
1993	male	0.0002	0.0009	0.0011	0.0055	0.0111	0.0207	0.0313	0.0476	0.0692	0.0898	0.0821	0.0714	0.0458	0.0233	0.0116	0.0029	0.0006	0.0011	0.0003	0.0000	0.0002
1994	female	0.0001	0.0004	0.0009	0.0023	0.0063	0.0132	0.0252	0.0393	0.0518	0.0636	0.0744	0.0734	0.0482	0.0297	0.0122	0.0045	0.0012	0.0006	0.0002	0.0002	0.0000
1994	male	0.0001	0.0005	0.0011	0.0028	0.0078	0.0163	0.0311	0.0485	0.0639	0.0786	0.0919	0.0906	0.0595	0.0366	0.0150	0.0055	0.0015	0.0007	0.0002	0.0002	0.0000
1995	female	0.0000	0.0003	0.0006	0.0023	0.0066	0.0208	0.0358	0.0622	0.0761	0.0775	0.0771	0.0537	0.0327	0.0178	0.0080	0.0028	0.0004	0.0003	0.0000	0.0000	0.0000
1995	male	0.0000	0.0004	0.0006	0.0026	0.0073	0.0230	0.0395	0.0688	0.0841	0.0855	0.0852	0.0593	0.0361	0.0197	0.0089	0.0030	0.0005	0.0004	0.0000	0.0000	0.0000
1996	female	0.0006	0.0005	0.0010	0.0039	0.0092	0.0159	0.0347	0.0589	0.0666	0.0805	0.0713	0.0581	0.0311	0.0142	0.0042	0.0016	0.0002	0.0001	0.0001	0.0001	0.0000
1996	male	0.0007	0.0005	0.0012	0.0047	0.0111	0.0192	0.0420	0.0712	0.0805	0.0973	0.0862	0.0702	0.0376	0.0171	0.0051	0.0019	0.0003	0.0001	0.0001	0.0001	0.0000
1997	female	0.0002	0.0004	0.0018	0.0039	0.0105	0.0220	0.0401	0.0728	0.0838	0.0795	0.0724	0.0568	0.0343	0.0195	0.0068	0.0032	0.0010	0.0003	0.0001	0.0001	0.0000
1997	male	0.0002	0.0004	0.0018	0.0037	0.0102	0.0212	0.0386	0.0701	0.0807	0.0765	0.0697	0.0547	0.0330	0.0187	0.0065	0.0031	0.0010	0.0003	0.0001	0.0001	0.0000
1998	female	0.0002	0.0006	0.0010	0.0048	0.0130	0.0204	0.0399	0.0630	0.0765	0.0769	0.0689	0.0562	0.0344	0.0176	0.0085	0.0018	0.0010	0.0003	0.0002	0.0001	0.0000
1998	male	0.0002	0.0006	0.0011	0.0051	0.0138	0.0216	0.0423	0.0668	0.0811	0.0815	0.0731	0.0596	0.0365	0.0187	0.0090	0.0019	0.0011	0.0004	0.0002	0.0001	0.0000
1999	female	0.0000	0.0005	0.0005	0.0018	0.0069	0.0230	0.0479	0.0759	0.0895	0.0873	0.0702	0.0471	0.0272	0.0129	0.0060	0.0021	0.0005	0.0005	0.0001	0.0000	0.0000
1999	male	0.0000	0.0005	0.0005	0.0018	0.0070	0.0230	0.0479	0.0760	0.0896	0.0874	0.0702	0.0472	0.0272	0.0129	0.0060	0.0021	0.0005	0.0005	0.0001	0.0000	0.0000
2000	female	0.0002	0.0003	0.0009	0.0025	0.0073	0.0155	0.0331	0.0701	0.1006	0.0956	0.0711	0.0451	0.0232	0.0093	0.0031	0.0011	0.0004	0.0001	0.0001	0.0000	0.0000
2000	male	0.0002	0.0003	0.0010	0.0027	0.0079	0.0168	0.0359	0.0760	0.1092	0.1038	0.0772	0.0490	0.0252	0.0101	0.0034	0.0011	0.0005	0.0001	0.0001	0.0000	0.0000
2001	female	0.0000	0.0007	0.0014	0.0029	0.0067	0.0132	0.0255	0.0492	0.0930	0.1150	0.0983	0.0605	0.0317	0.0154	0.0050	0.0027	0.0011	0.0005	0.0001	0.0000	0.0000
2001	male	0.0000	0.0006	0.0013	0.0027	0.0061	0.0120	0.0233	0.0449	0.0848	0.1049	0.0896	0.0552	0.0290	0.0141	0.0046	0.0025	0.0010	0.0004	0.0001	0.0000	0.0000
2002	combined	0.0000	0.0000	0.0026	0.0065	0.0243	0.0335	0.0604	0.0791	0.1278	0.1887	0.1939	0.1343	0.0839	0.0400	0.0143	0.0070	0.0013	0.0013	0.0009	0.0000	0.0000

Table 6. Sex-specific length compositions for black rockfish taken in the Oregon hook-and-line fishery (1992, 1995-2002).

		Fork Length [cm]																				
Year	Sex	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60
1992	female	0.0000	0.0000	0.0000	0.0000	0.0000	0.0032	0.0300	0.0056	0.0608	0.0727	0.0995	0.0787	0.0406	0.0696	0.0181	0.0314	0.0129	0.0000	0.0000	0.0000	0.0000
1992	male	0.0000	0.0000	0.0000	0.0000	0.0000	0.0165	0.0011	0.0011	0.0216	0.0251	0.0687	0.1100	0.0810	0.0907	0.0354	0.0143	0.0061	0.0050	0.0000	0.0000	0.0000
1995	female	0.0000	0.0000	0.0000	0.0000	0.0000	0.0049	0.0374	0.0407	0.0654	0.0757	0.0578	0.0681	0.0577	0.0474	0.0227	0.0102	0.0016	0.0027	0.0000	0.0000	0.0000
1995	male	0.0000	0.0000	0.0000	0.0000	0.0000	0.0031	0.0285	0.0531	0.0485	0.0658	0.0988	0.0724	0.1008	0.0243	0.0103	0.0008	0.0009	0.0000	0.0000	0.0000	0.0000
1996	female	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0077	0.0256	0.0728	0.0729	0.1064	0.0528	0.0843	0.0404	0.0257	0.0096	0.0000	0.0000	0.0000	0.0000	0.0000
1996	male	0.0000	0.0000	0.0000	0.0000	0.0000	0.0029	0.0000	0.0206	0.0466	0.0616	0.0905	0.1570	0.0959	0.0239	0.0028	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1997	female	0.0000	0.0000	0.0000	0.0007	0.0037	0.0043	0.0067	0.0416	0.0563	0.0413	0.0737	0.0637	0.0484	0.0681	0.0037	0.0415	0.0038	0.0241	0.0080	0.0000	0.0000
1997	male	0.0000	0.0000	0.0005	0.0016	0.0016	0.0070	0.0092	0.0225	0.0243	0.0448	0.0581	0.1359	0.0795	0.0861	0.0025	0.0367	0.0000	0.0000	0.0000	0.0000	0.0000
1998	female	0.0000	0.0000	0.0000	0.0000	0.0000	0.0043	0.0190	0.0254	0.0415	0.1008	0.0800	0.0514	0.0645	0.0426	0.0335	0.0053	0.0056	0.0000	0.0076	0.0000	0.0000
1998	male	0.0000	0.0000	0.0000	0.0027	0.0015	0.0098	0.0223	0.0296	0.0663	0.0634	0.1114	0.0826	0.0726	0.0208	0.0216	0.0075	0.0066	0.0000	0.0000	0.0000	0.0000
1999	female	0.0000	0.0000	0.0000	0.0185	0.0000	0.0159	0.0397	0.1130	0.1097	0.0640	0.0534	0.0962	0.0166	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1999	male	0.0000	0.0000	0.0000	0.0000	0.0118	0.0118	0.0451	0.0231	0.1016	0.0891	0.0784	0.0477	0.0289	0.0237	0.0118	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2000	female	0.0000	0.0000	0.0000	0.0000	0.0022	0.0158	0.0229	0.0505	0.1006	0.1021	0.0705	0.0540	0.0492	0.0130	0.0116	0.0000	0.0058	0.0032	0.0000	0.0000	0.0000
2000	male	0.0000	0.0000	0.0000	0.0006	0.0013	0.0057	0.0123	0.0654	0.0885	0.1128	0.0737	0.0597	0.0370	0.0281	0.0091	0.0022	0.0022	0.0000	0.0000	0.0000	0.0000
2001	female	0.0000	0.0000	0.0000	0.0000	0.0006	0.0024	0.0187	0.0264	0.0662	0.0903	0.1159	0.0700	0.0701	0.0172	0.0230	0.0010	0.0004	0.0003	0.0000	0.0000	0.0000
2001	male	0.0000	0.0000	0.0000	0.0000	0.0004	0.0007	0.0046	0.0169	0.0595	0.0875	0.1534	0.0787	0.0602	0.0221	0.0122	0.0004	0.0000	0.0000	0.0008	0.0000	0.0000
2002	female	0.0000	0.0000	0.0000	0.0000	0.0000	0.0029	0.0150	0.0293	0.0471	0.0786	0.0873	0.0781	0.0841	0.0353	0.0178	0.0162	0.0003	0.0000	0.0000	0.0000	0.0000
2002	male	0.0000	0.0000	0.0000	0.0000	0.0000	0.0023	0.0068	0.0216	0.0401	0.0721	0.1375	0.1313	0.0488	0.0390	0.0081	0.0004	0.0000	0.0000	0.0000	0.0000	0.0000

Table 7. Combined sex length compositions for black rockfish taken in the Oregon trawl fishery (1994, 1997, 1998, 2001).

		Fork Length [cm]																				
year	sex	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60
1994	combined	0.0000	0.0000	0.0000	0.0000	0.0000	0.0488	0.0000	0.0245	0.0977	0.1952	0.0732	0.1220	0.1949	0.1706	0.0488	0.0243	0.0000	0.0000	0.0000	0.0000	0.0000
1997	combined	0.0000	0.0000	0.0000	0.0000	0.0000	0.0043	0.0000	0.0000	0.0000	0.0192	0.0384	0.1738	0.2391	0.2379	0.1561	0.0776	0.0382	0.0153	0.0000	0.0000	0.0000
1998	combined	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0016	0.0000	0.0287	0.1142	0.1747	0.2057	0.1637	0.1879	0.0857	0.0062	0.0285	0.0031	0.0000	0.0000
2001	combined	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.4725	0.1324	0.0000	0.2627	0.0265	0.0530	0.0265	0.0265	0.0000	0.0000	0.0000

Table 8. Combined sex length compositions for black rockfish taken in the northern California recreational fishery (1980-2002).

		Fork Length [cm]																				
Year	Sex	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60
1980	combined	0.0000	0.0020	0.0059	0.0176	0.0332	0.0664	0.1074	0.1094	0.0820	0.0879	0.0996	0.0801	0.1035	0.0801	0.0566	0.0430	0.0156	0.0078	0.0000	0.0020	0.0000
1981	combined	0.0000	0.0021	0.0000	0.0166	0.0229	0.0312	0.0374	0.1102	0.1164	0.1102	0.0894	0.1019	0.1372	0.0832	0.0748	0.0437	0.0083	0.0125	0.0021	0.0000	0.0000
1982	combined	0.0017	0.0035	0.0000	0.0052	0.0175	0.0750	0.0820	0.0733	0.0733	0.0733	0.1030	0.1274	0.0855	0.0890	0.0890	0.0489	0.0384	0.0017	0.0105	0.0017	0.0000
1983	combined	0.0000	0.0026	0.0026	0.0026	0.0205	0.0462	0.0821	0.1051	0.0923	0.0974	0.1205	0.1026	0.0974	0.0769	0.0872	0.0410	0.0077	0.0077	0.0051	0.0026	0.0000
1984	combined	0.0016	0.0032	0.0273	0.0353	0.0770	0.0594	0.1059	0.0899	0.0690	0.0770	0.0963	0.0803	0.1252	0.0690	0.0465	0.0177	0.0096	0.0064	0.0032	0.0000	0.0000
1985	combined	0.0022	0.0073	0.0146	0.0321	0.0774	0.1314	0.1350	0.1161	0.0803	0.0679	0.0810	0.0577	0.0599	0.0584	0.0423	0.0212	0.0131	0.0022	0.0000	0.0000	0.0000
1986	combined	0.0029	0.0029	0.0048	0.0213	0.0397	0.0735	0.1064	0.1199	0.0861	0.0957	0.1054	0.1006	0.0706	0.0793	0.0464	0.0193	0.0174	0.0058	0.0019	0.0000	0.0000
1987	combined	0.0106	0.0106	0.0211	0.0529	0.0973	0.0930	0.1332	0.1057	0.1416	0.0825	0.0613	0.0148	0.0402	0.0507	0.0423	0.0233	0.0085	0.0063	0.0000	0.0021	0.0021
1988	combined	0.0033	0.0133	0.0398	0.1044	0.0754	0.0729	0.1036	0.1301	0.0845	0.0721	0.0406	0.0398	0.0505	0.0547	0.0605	0.0307	0.0141	0.0058	0.0033	0.0008	0.0000
1989	combined	0.0007	0.0062	0.0201	0.0408	0.0734	0.1370	0.1730	0.1502	0.1114	0.0519	0.0429	0.0464	0.0346	0.0471	0.0311	0.0166	0.0097	0.0069	0.0000	0.0000	0.0000
1990	combined	0.0038	0.0077	0.0613	0.0843	0.0843	0.2222	0.2759	0.1724	0.0575	0.0192	0.0115	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1991	combined	0.0038	0.0345	0.0384	0.1420	0.1958	0.1823	0.1785	0.1286	0.0672	0.0192	0.0000	0.0038	0.0019	0.0019	0.0000	0.0000	0.0000	0.0000	0.0019	0.0000	0.0000
1992	combined	0.0000	0.0052	0.0104	0.0547	0.1302	0.1198	0.2109	0.1380	0.1042	0.0573	0.0443	0.0365	0.0260	0.0365	0.0156	0.0078	0.0026	0.0000	0.0000	0.0000	0.0000
1993	combined	0.0020	0.0071	0.0360	0.0826	0.1145	0.1597	0.1389	0.1029	0.0679	0.0573	0.0507	0.0669	0.0446	0.0319	0.0198	0.0117	0.0030	0.0015	0.0010	0.0000	0.0000
1994	combined	0.0073	0.0114	0.0322	0.0716	0.1235	0.1796	0.1832	0.1090	0.0903	0.0503	0.0337	0.0348	0.0296	0.0218	0.0161	0.0026	0.0016	0.0010	0.0000	0.0005	0.0000
1995	combined	0.0026	0.0093	0.0622	0.1390	0.1899	0.2197	0.1198	0.0668	0.0470	0.0371	0.0318	0.0212	0.0185	0.0132	0.0073	0.0053	0.0040	0.0013	0.0013	0.0000	0.0026
1996	combined	0.0000	0.0114	0.0204	0.0541	0.1188	0.1540	0.1510	0.1207	0.0772	0.0605	0.0681	0.0530	0.0488	0.0341	0.0174	0.0057	0.0011	0.0030	0.0008	0.0000	0.0000
1997	combined	0.0029	0.0198	0.0595	0.1450	0.1924	0.2152	0.1452	0.1037	0.0579	0.0230	0.0115	0.0083	0.0075	0.0056	0.0013	0.0011	0.0000	0.0000	0.0000	0.0000	0.0000
1998	combined	0.0038	0.0063	0.0347	0.0859	0.1768	0.2273	0.1313	0.0840	0.0385	0.0366	0.0505	0.0417	0.0360	0.0227	0.0126	0.0051	0.0044	0.0013	0.0006	0.0000	0.0000
1999	combined	0.0030	0.0079	0.0225	0.0596	0.1163	0.2642	0.2605	0.1656	0.0584	0.0207	0.0110	0.0043	0.0030	0.0018	0.0006	0.0000	0.0006	0.0000	0.0000	0.0000	0.0000
2000	combined	0.0000	0.0039	0.0146	0.0527	0.0956	0.2937	0.3161	0.1307	0.0468	0.0107	0.0088	0.0059	0.0049	0.0068	0.0039	0.0000	0.0000	0.0000	0.0039	0.0010	0.0000
2001	combined	0.0039	0.0088	0.0215	0.0371	0.0713	0.1494	0.2207	0.2139	0.1074	0.0557	0.0430	0.0283	0.0088	0.0049	0.0117	0.0117	0.0000	0.0010	0.0010	0.0000	0.0000
2002	combined	0.0040	0.0103	0.0459	0.0878	0.0965	0.1108	0.1590	0.1582	0.1566	0.0672	0.0332	0.0237	0.0158	0.0103	0.0079	0.0087	0.0024	0.0008	0.0000	0.0008	0.0000

Table 9. Combined sex length compositions for black rockfish taken in the northern California hook-and-line fishery (1982-2002).

		Fork Length [cm]																				
year	sex	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60
1982	combined	0.0000	0.0000	0.0000	0.0000	0.0000	0.0188	0.0188	0.0375	0.1167	0.1202	0.0375	0.1202	0.1466	0.1953	0.0980	0.0452	0.0188	0.0264	0.0000	0.0000	0.0000
1983	combined	0.0000	0.0000	0.0000	0.0000	0.0000	0.0090	0.0000	0.0202	0.0179	0.0355	0.0940	0.2454	0.2310	0.1529	0.0883	0.0707	0.0352	0.0000	0.0000	0.0000	0.0000
1984	combined	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0677	0.0417	0.0209	0.1433	0.3204	0.1980	0.1613	0.0338	0.0130	0.0000	0.0000	0.0000	0.0000
1985	combined	0.0000	0.0000	0.0000	0.0000	0.0000	0.0323	0.0323	0.0323	0.0323	0.1290	0.0968	0.1935	0.1613	0.1613	0.1290	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1992	combined	0.0000	0.0000	0.0019	0.0072	0.0102	0.0111	0.0302	0.0491	0.0858	0.1398	0.1960	0.1669	0.1097	0.0838	0.0792	0.0260	0.0028	0.0000	0.0003	0.0000	0.0000
1993	combined	0.0000	0.0008	0.0239	0.0435	0.0634	0.0608	0.0721	0.0909	0.1080	0.1302	0.1387	0.1146	0.0764	0.0412	0.0190	0.0091	0.0043	0.0006	0.0000	0.0005	0.0019
1994	combined	0.0002	0.0010	0.0054	0.0094	0.0203	0.0548	0.0813	0.1206	0.1083	0.1307	0.1180	0.1416	0.0812	0.0649	0.0290	0.0190	0.0076	0.0060	0.0007	0.0000	0.0000
1995	combined	0.0000	0.0006	0.0001	0.0016	0.0184	0.0528	0.0985	0.1141	0.1092	0.1528	0.1398	0.1201	0.0851	0.0577	0.0262	0.0063	0.0096	0.0041	0.0030	0.0000	0.0000
1996	combined	0.0108	0.0108	0.0215	0.0779	0.0378	0.0715	0.0965	0.0868	0.1321	0.1110	0.1009	0.0997	0.0660	0.0455	0.0208	0.0079	0.0019	0.0007	0.0000	0.0000	0.0000
1997	combined	0.0000	0.0000	0.0096	0.0077	0.0234	0.0431	0.0841	0.1547	0.1602	0.1527	0.1159	0.0980	0.0735	0.0517	0.0180	0.0063	0.0011	0.0000	0.0000	0.0000	0.0000
1998	combined	0.0000	0.0000	0.0000	0.0000	0.0029	0.0441	0.0487	0.1452	0.1379	0.1748	0.1751	0.1706	0.0530	0.0257	0.0126	0.0093	0.0000	0.0000	0.0000	0.0000	0.0000
1999	combined	0.0000	0.0000	0.0000	0.0021	0.0028	0.0193	0.0564	0.1322	0.1724	0.1805	0.1594	0.1074	0.0775	0.0428	0.0249	0.0170	0.0035	0.0017	0.0000	0.0000	0.0000
2000	combined	0.0000	0.0000	0.0000	0.0000	0.0057	0.0203	0.0583	0.0997	0.1510	0.1902	0.1640	0.1320	0.0809	0.0681	0.0182	0.0056	0.0011	0.0047	0.0000	0.0000	0.0000
2001	combined	0.0000	0.0000	0.0000	0.0025	0.0016	0.0120	0.0545	0.0850	0.1469	0.1999	0.2000	0.1794	0.0669	0.0217	0.0261	0.0032	0.0002	0.0000	0.0000	0.0000	0.0000
2002	combined	0.0000	0.0000	0.0000	0.0012	0.0130	0.0213	0.0518	0.0738	0.1270	0.1790	0.1825	0.1223	0.0866	0.0733	0.0401	0.0204	0.0023	0.0055	0.0000	0.0000	0.0000

Table 10. Combined sex length compositions for black rockfish taken in the northen California trawl fishery (1978-1999).

		Fork Length [cm]																				
Year	Sex	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60
1978	combined	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1418	0.1865	0.2236	0.1016	0.0630	0.1031	0.0864	0.0137	0.0228	0.0493	0.0000	0.0083
1980	combined	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0028	0.0456	0.0615	0.1618	0.1093	0.2275	0.1611	0.1231	0.0062	0.0629	0.0284	0.0055	0.0041
1981	combined	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0385	0.0385	0.0035	0.0373	0.0739	0.0895	0.1340	0.1523	0.2152	0.1236	0.0508	0.0080	0.0267	0.0084	0.0000
1982	combined	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0387	0.1423	0.1204	0.1129	0.2128	0.1814	0.1166	0.0699	0.0045	0.0002	0.0000	0.0000
1983	combined	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0096	0.0096	0.1030	0.1157	0.2230	0.1916	0.2137	0.0768	0.0293	0.0144	0.0120	0.0007	0.0005
1984	combined	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0173	0.1077	0.2699	0.2367	0.1117	0.1529	0.0412	0.0505	0.0066	0.0053	0.0000
1985	combined	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0291	0.0520	0.1590	0.2420	0.1177	0.2549	0.0775	0.0339	0.0339	0.0000	0.0000
1987	combined	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0040	0.0121	0.0464	0.0539	0.1629	0.2105	0.1916	0.1411	0.0971	0.0727	0.0069	0.0008
1988	combined	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0123	0.0162	0.2270	0.0349	0.2309	0.1185	0.1636	0.1421	0.0547	0.0000
1989	combined	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0047	0.0000	0.0093	0.1131	0.0673	0.2290	0.1402	0.2879	0.0879	0.0290	0.0243	0.0075
1991	combined	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0515	0.0000	0.1802	0.0000	0.1470	0.2426	0.3015	0.0515	0.0257	0.0000	0.0000	0.0000	0.0000
1992	combined	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0046	0.1030	0.0671	0.3693	0.1516	0.1701	0.0543	0.0266	0.0266	0.0000	0.0266	0.0000
1996	combined	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0800	0.0400	0.0800	0.2400	0.1600	0.1200	0.1200	0.0000	0.0800	0.0800	0.0000
1997	combined	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0030	0.0000	0.0488	0.1500	0.1283	0.2843	0.1590	0.0398	0.1500	0.0367	0.0000	0.0000
1999	combined	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0400	0.0000	0.0000	0.0400	0.1600	0.2400	0.2000	0.0400	0.1600	0.0400	0.0400	0.0400	0.0000

Table 11. Likelihood components from the base model.

Component	Emphasis	log-Likelihood
OR Sport Age Compositions	1.00	-169.95
OR Sport Length Compositions	1.00	-345.04
OR Sport Length @ Age	0.10	-2177.19
OR Hook-and-line Length Compositions	1.00	-90.77
OR Trawl Length Compositions	1.00	-35.37
CA Sport Length Compositions	1.00	-179.49
CA Hook-and-line Length Compositions	1.00	-124.35
CA Trawl Length Compositions	1.00	-101.46
OR RECFIN CPUE	1.00	11.11
OR ODF&W CPUE	1.00	8.79
CA RECFIN CPUE	1.00	8.39
CA CDF&G CPUE	1.00	1.98

Table 12. Base model outputs of population trend from the stock synthesis model.

Year	Age 2+ biomass	Spawning Output	Age 2 Recruits	Catch	Depletion
1945	20,510	3,144,660	2,665	0	100.0%
1946	20,515	3,144,656	2,665	39	100.0%
1947	20,488	3,137,664	2,665	79	99.8%
1948	20,429	3,124,300	2,665	118	99.4%
1949	20,343	3,105,440	2,664	157	98.8%
1950	20,230	3,081,864	2,662	197	98.0%
1951	20,094	3,054,112	2,660	236	97.1%
1952	19,935	3,022,598	2,658	276	96.1%
1953	19,756	2,987,689	2,655	315	95.0%
1954	19,559	2,949,664	2,651	354	93.8%
1955	19,344	2,908,637	2,647	378	92.5%
1956	19,127	2,867,876	2,643	427	91.2%
1957	18,886	2,822,325	2,638	462	89.7%
1958	18,636	2,775,204	2,633	481	88.3%
1959	18,390	2,729,732	2,627	459	86.8%
1960	18,183	2,693,445	2,621	467	85.7%
1961	17,985	2,659,520	2,615	430	84.6%
1962	17,831	2,636,094	2,610	426	83.8%
1963	17,690	2,615,718	2,605	476	83.2%
1964	17,515	2,587,293	2,602	459	82.3%
1965	17,365	2,564,296	2,599	519	81.5%
1966	17,169	2,531,879	2,594	588	80.5%
1967	16,923	2,489,712	2,591	637	79.2%
1968	16,647	2,442,234	2,586	574	77.7%
1969	16,444	2,410,467	2,579	685	76.7%
1970	16,149	2,360,400	2,572	775	75.1%
1971	15,792	2,296,956	2,567	694	73.0%
1972	15,530	2,253,688	2,558	743	71.7%
1973	15,238	2,204,445	2,547	763	70.1%
1974	14,944	2,154,721	2,539	831	68.5%
1975	14,403	2,095,805	1,100	936	66.6%
1976	13,759	2,021,053	1,602	1,119	64.3%
1977	12,948	1,915,076	2,140	937	60.9%
1978	12,506	1,839,876	3,573	1,042	58.5%
1979	11,912	1,725,506	2,187	1,099	54.9%
1980	11,346	1,587,449	2,013	734	50.5%
1981	11,182	1,523,701	2,119	1,836	48.5%
1982	10,014	1,288,784	2,123	1,636	41.0%
1983	9,016	1,138,092	1,846	1,325	36.2%
1984	8,464	1,031,295	2,535	1,273	32.8%
1985	7,929	952,645	1,982	1,187	30.3%
1986	7,702	887,570	3,325	816	28.2%
1987	7,838	881,285	2,601	664	28.0%
1988	8,069	900,041	1,634	916	28.6%
1989	8,095	896,821	2,110	1,018	28.5%
1990	7,989	900,920	2,261	896	28.6%
1991	8,013	939,267	2,694	711	29.9%
1992	8,252	988,993	2,870	1,194	31.4%
1993	8,012	948,032	2,569	886	30.1%
1994	8,171	948,605	3,062	847	30.2%
1995	8,442	956,929	3,206	858	30.4%
1996	8,966	971,532	4,669	903	30.9%
1997	9,519	990,796	4,004	879	31.5%
1998	9,951	1,029,952	1,835	827	32.8%
1999	10,412	1,108,658	2,093	727	35.3%
2000	10,807	1,244,148	2,118	602	39.6%
2001	11,172	1,412,334	2,165	769	44.9%
2002	11,232	1,536,076	2,236	617	48.8%

Table 13. Length-specific summary of black rockfish population characteristics in the terminal year of the base model.

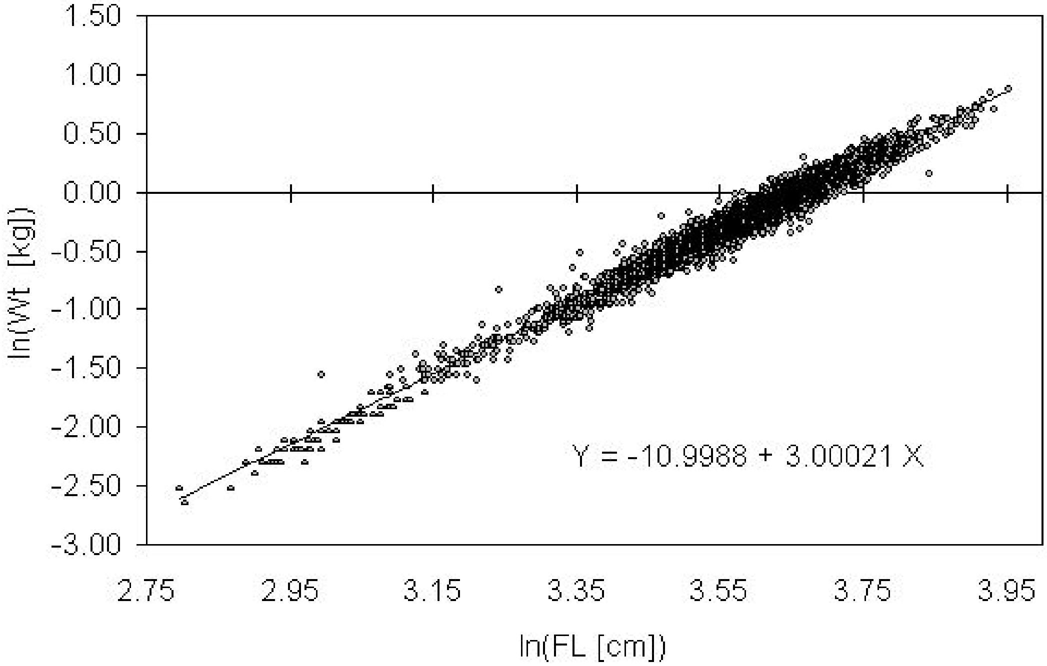
					Selectivities					
FL[cm]	Wt [kg]	larvae/gm	% mature	Spawn	OR sport	OR hook	OR trawl	CA sport	CA hook	CA trawl
20	0.14	305.7	0.000	0	0.001	0.001	0.001	0.001	0.001	0.001
22	0.18	310.7	0.001	0	0.009	0.002	0.001	0.205	0.014	0.001
24	0.23	316.7	0.002	0	0.024	0.003	0.001	0.405	0.036	0.001
26	0.30	323.8	0.004	0	0.055	0.008	0.001	0.591	0.075	0.001
28	0.37	332.0	0.009	1	0.112	0.020	0.001	0.755	0.140	0.002
30	0.46	341.4	0.021	3	0.211	0.051	0.002	0.891	0.240	0.002
32	0.55	352.0	0.047	9	0.362	0.131	0.004	1.000	0.382	0.004
34	0.66	364.1	0.100	24	0.554	0.302	0.011	1.000	0.554	0.007
36	0.79	377.6	0.198	59	0.747	0.568	0.032	0.782	0.732	0.016
38	0.92	392.6	0.354	128	0.900	0.832	0.091	0.379	0.886	0.034
40	1.08	409.3	0.546	241	1.000	1.000	0.239	0.276	1.000	0.076
42	1.25	427.7	0.726	387	1.000	1.000	0.498	0.266	1.000	0.160
44	1.43	447.8	0.855	549	0.731	0.933	0.757	0.265	0.829	0.308
46	1.64	469.9	0.930	716	0.480	0.734	0.908	0.265	0.662	0.510
48	1.86	493.8	0.968	890	0.332	0.484	0.969	0.265	0.525	0.710
50	2.10	519.9	0.985	1078	0.267	0.369	0.990	0.265	0.427	0.852
52	2.37	548.0	0.994	1289	0.242	0.340	0.997	0.265	0.363	0.932
54	2.65	578.4	0.997	1529	0.233	0.333	0.999	0.265	0.325	0.971
56	2.96	611.0	0.999	1804	0.230	0.332	1.000	0.265	0.303	0.989
58	3.28	636.7	0.999	2089	0.229	0.332	1.000	0.265	0.291	0.997
60	3.45	645.4	1.000	2228	0.229	0.332	1.000	0.265	0.284	1.000

Table 14. Projected optimum yield (OY) under the base assessment model and under two alternative views of the level of historical catch prior to 1978.

	Low Catch Scenario		Base Model		High Catch Scenario	
Year	OY [mt]	Depletion	OY [mt]	Depletion	OY [mt]	Depletion
2003	757	54.2%	802	51.9%	886	48.1%
2004	729	54.9%	775	52.7%	861	49.0%
2005	706	54.5%	753	52.5%	842	48.9%
2006	688	53.3%	736	51.4%	828	48.2%
2007	676	51.7%	725	50.0%	820	47.1%
2008	668	50.3%	719	48.8%	817	46.2%
2009	663	49.2%	715	47.9%	816	45.6%
2010	660	48.3%	713	47.2%	816	45.1%
2011	657	47.7%	711	46.7%	816	44.9%
2012	654	47.2%	708	46.3%	816	44.7%

Table 15. Decision table describing the conservation consequences of management errors that arise from incorrect assumptions about the true state of nature (i.e., the historical catch of black rockfish prior to 1978). Consequences are measured as the amount of spawning depletion following 5 years of management under each scenario.

	"True" State of Nature		
	Low Catch History	Base Model	High Catch History
Mean $F_{50\%}$ ABC $\Rightarrow$	711 mt	758 mt	847 mt
Management Action (2003-2007 mean harvest)		Total Spawning Depletion After 5 Years of Harvest	
711 mt:	51.7%	51.2%	49.7%
758 mt:	50.7%	50.0%	48.9%
847 mt:	48.3%	48.1%	47.1%



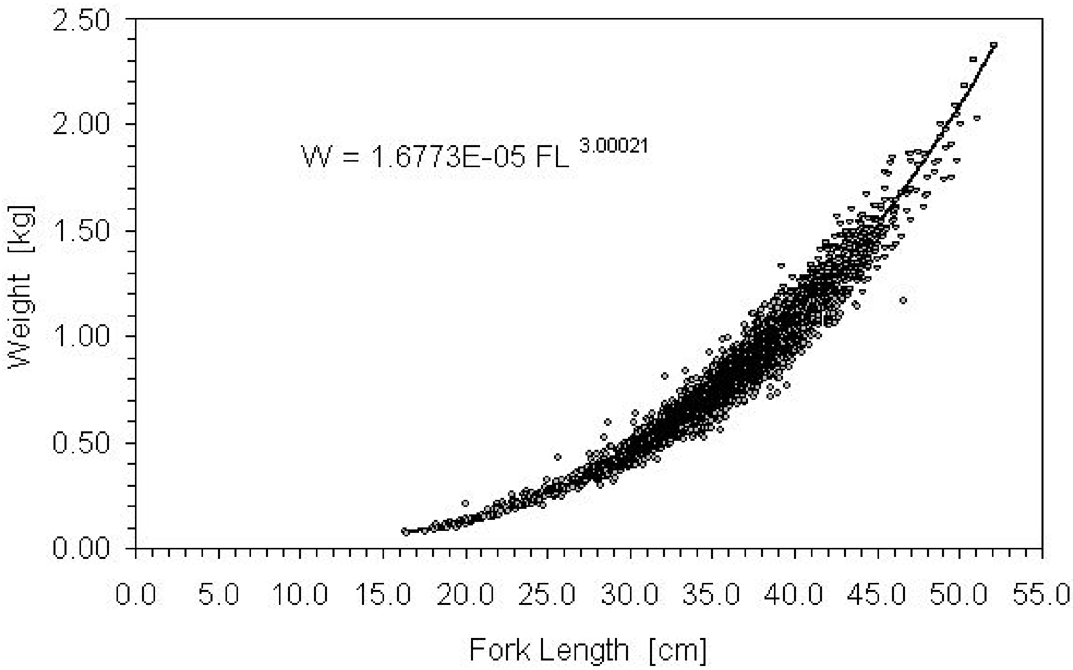
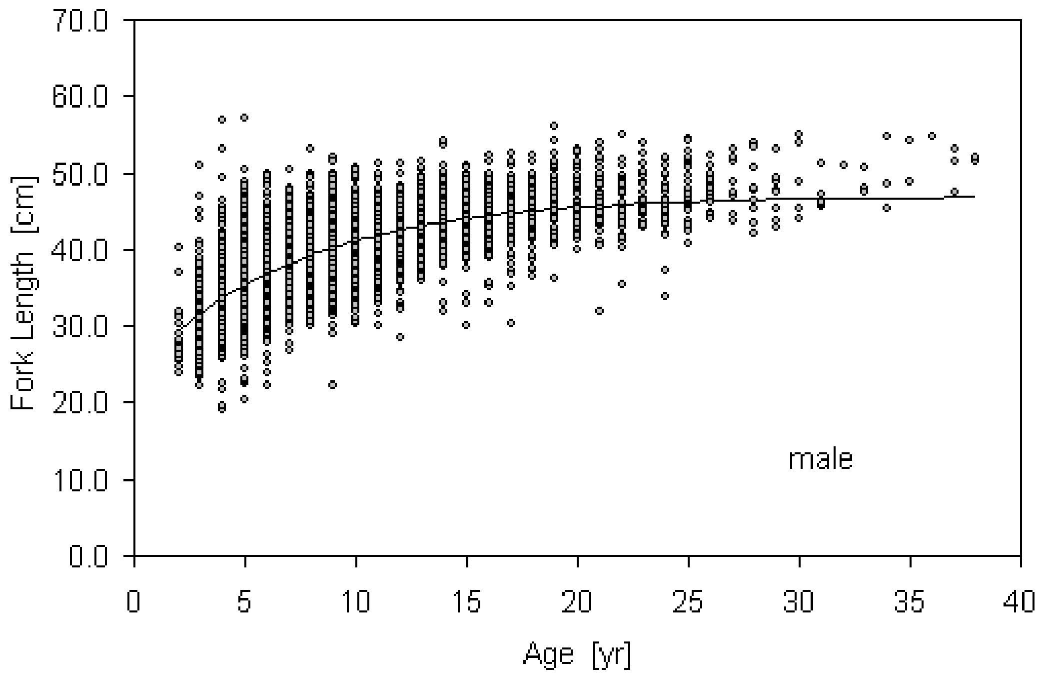


Figure 1. Length-weight relationship for black rockfish derived from fish sampled in the Oregon recreational fishery.



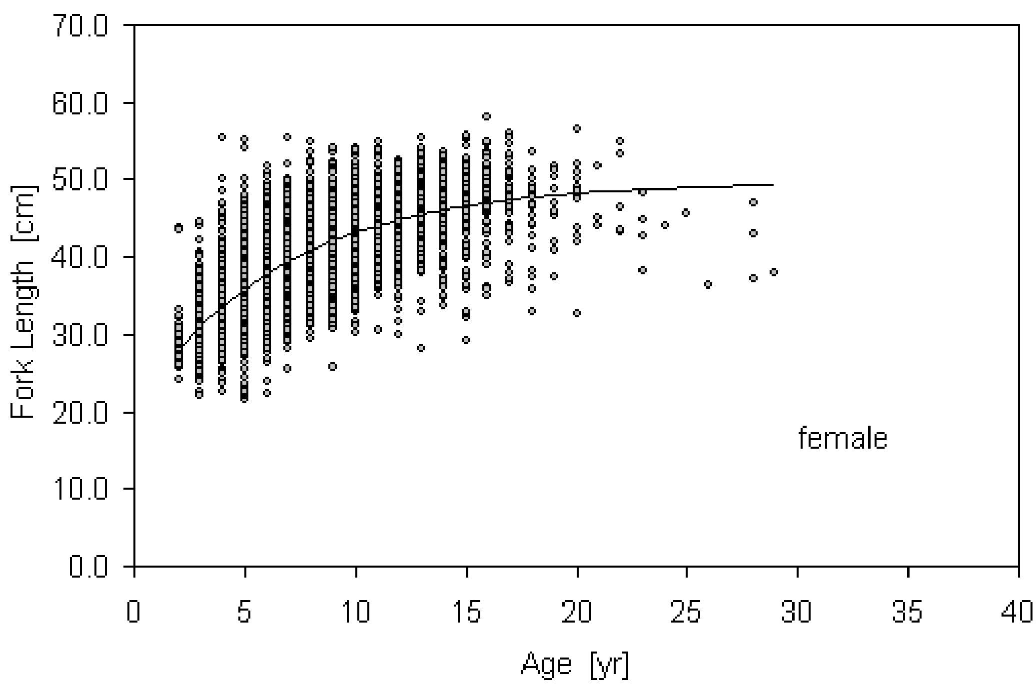


Figure 2. Fit of the von Bertalanffy growth model to black rockfish sampled from the Oregon recreational fishery.

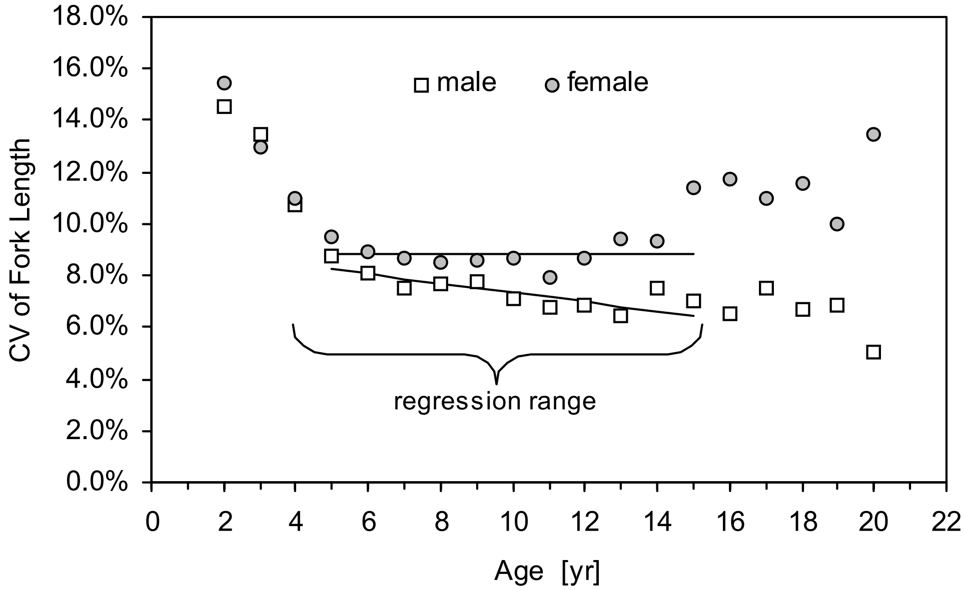


Figure 3. Variation in black rockfish fork length (FL) at age. Separate regressions were used to predict the sex-specific coefficients of variation for length variability at 5 and 15 years of age.

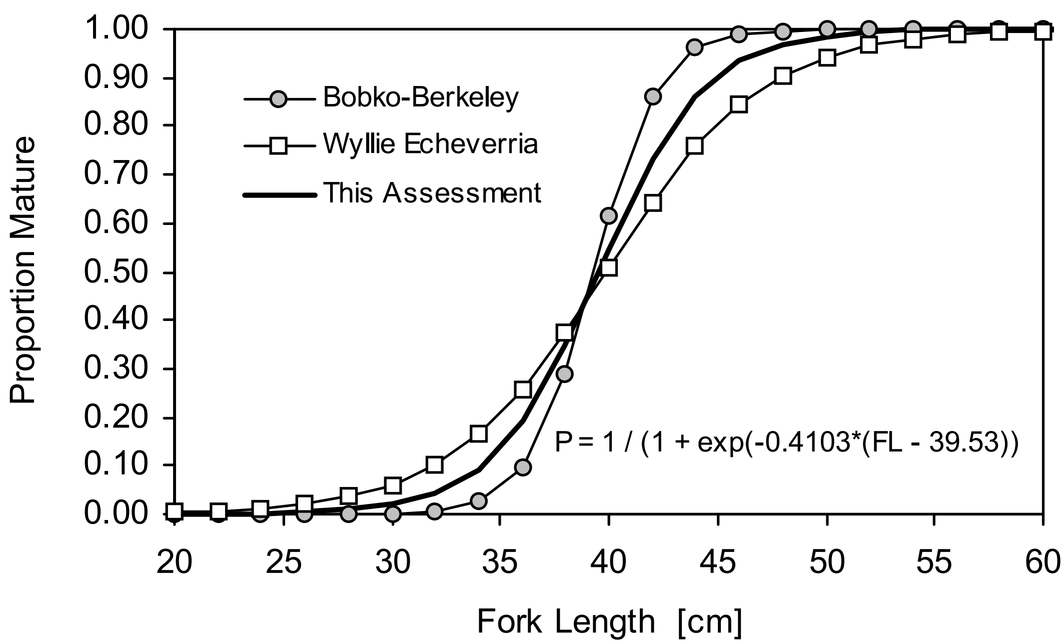


Figure 4. The relationship between black rockfish length and maturity.

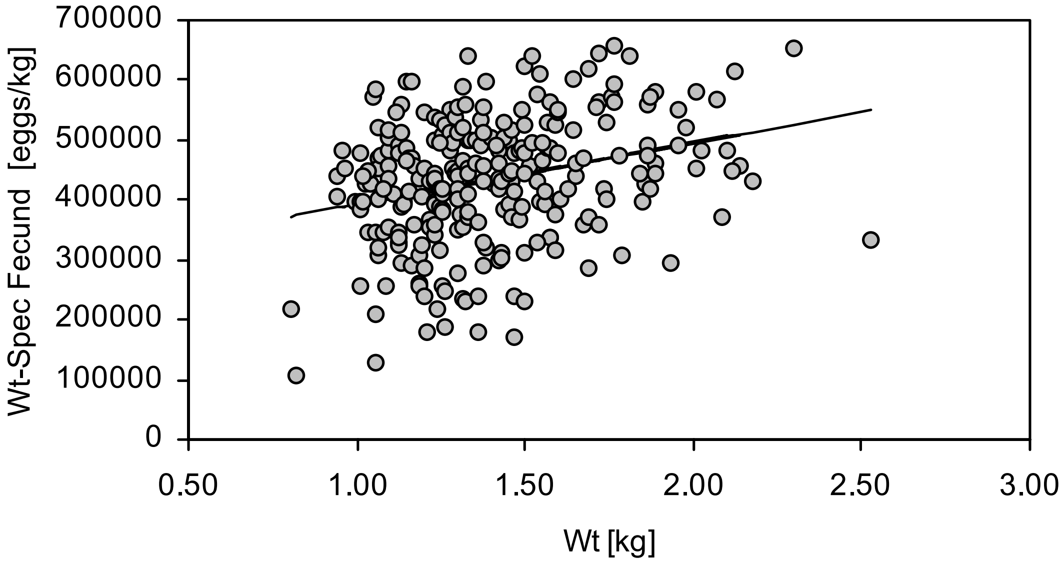


Figure 5. The dependence of weight-specific fecundity on female weight for black rockfish sampled in Oregon.

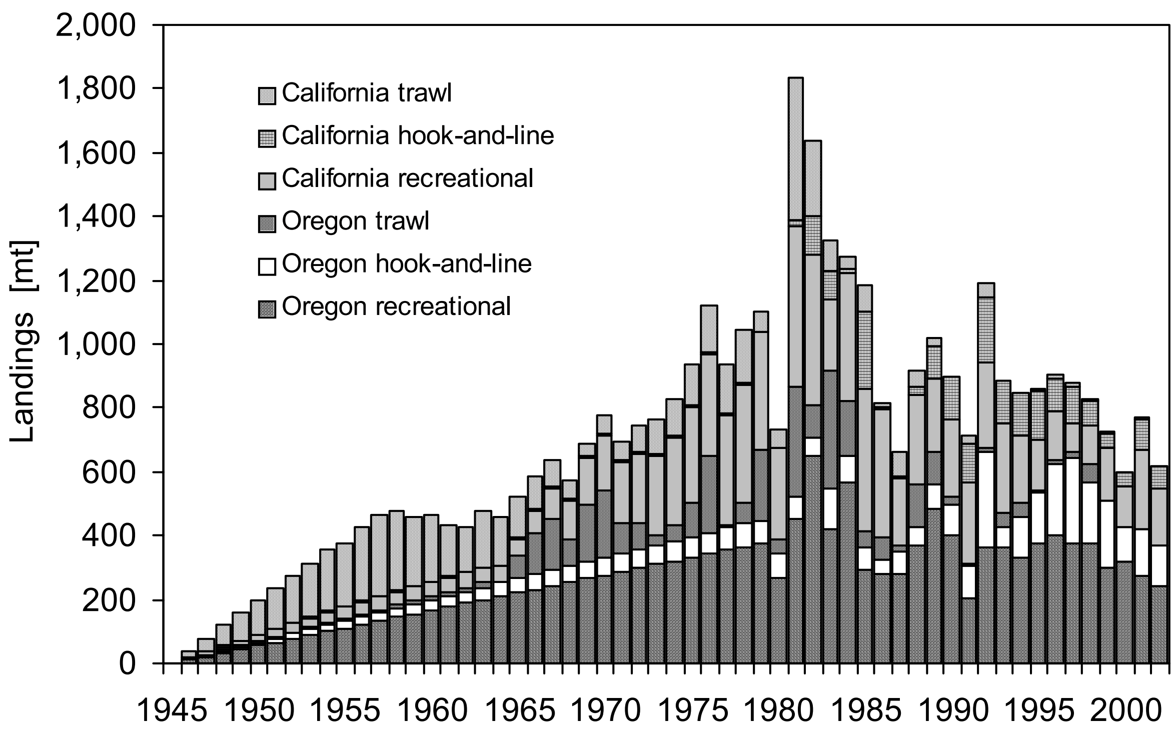


Figure 6. Estimated landings of black rockfish by fishery and State for the period 1945-2002. Landings information prior to 1978 were sparse and missing values were estimated by linear interpolation.

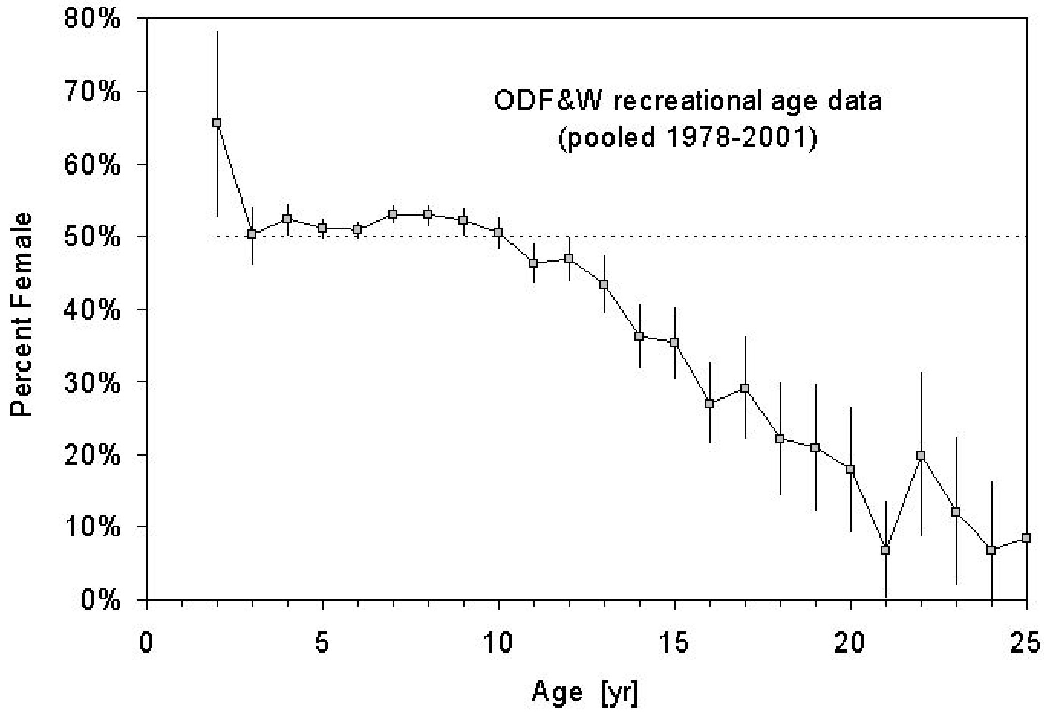


Figure 7. Decline in the relative abundance of females with age in the Oregon recreational fishery. The deficit of females after age 10 was interpreted as an increase in the natural mortality rate at that age.

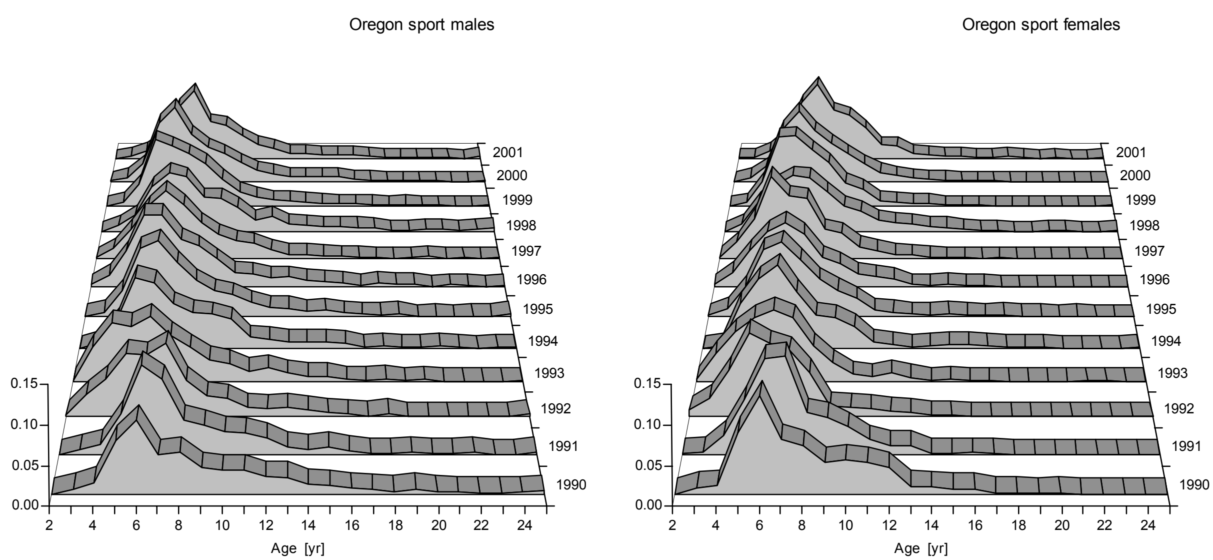


Figure 8. Age-frequency distributions for male (left) and female (right) black rockfish sampled from the Oregon recreational fishery (1990-2001). [ODF&W data]

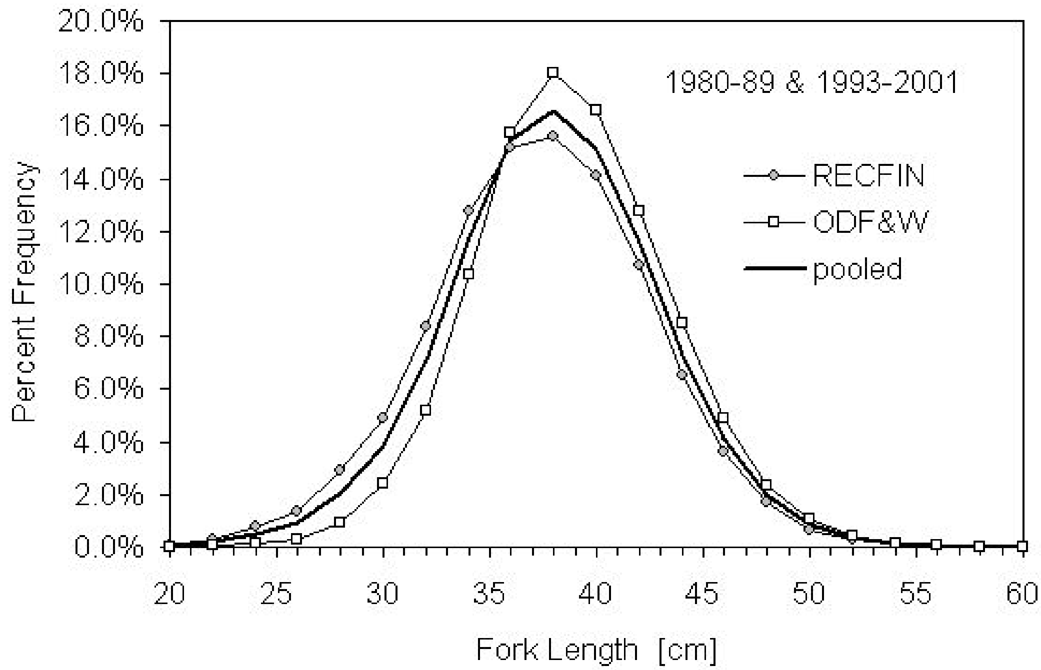


Figure 9. Comparison of Oregon recreational length-frequency data for samples obtained from RECFIN and ODF&W.

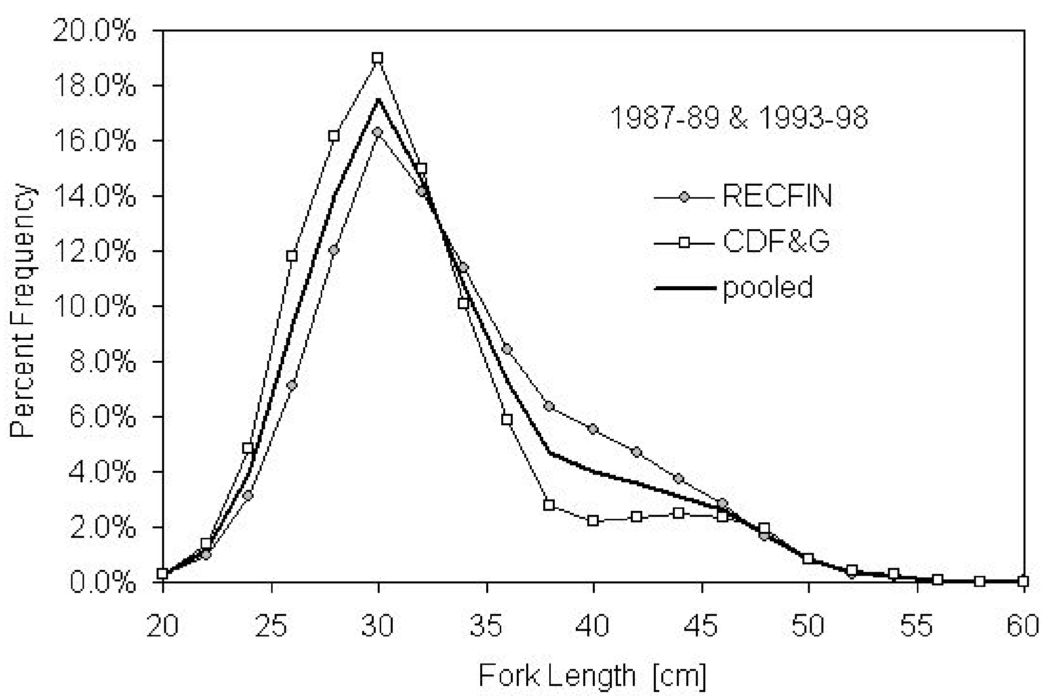


Figure 10. Comparison of northern California recreational length-frequency data for samples obtained from RECFIN and CDF&G.

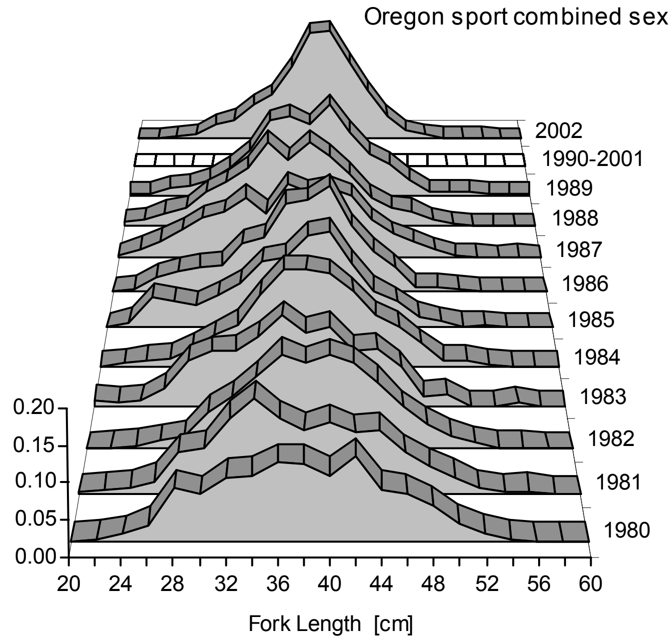


Figure 11. Length-frequency distributions for combined sex black rockfish sampled from the Oregon recreational fishery (1980-89 and 2002). [RECFIN data only]

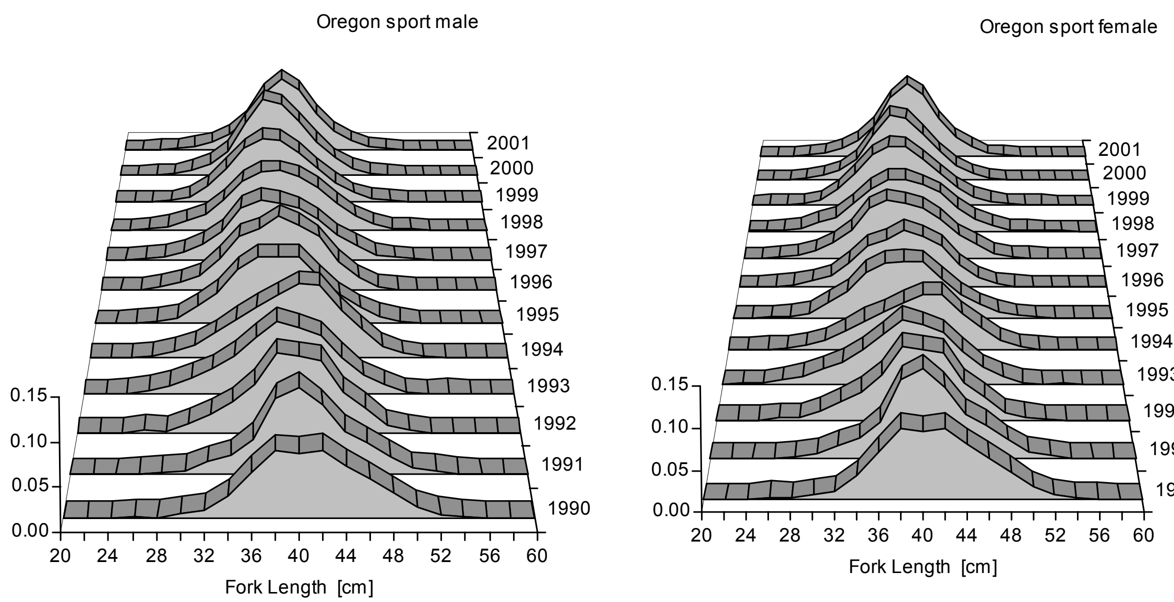


Figure 12. Length-frequency distributions for male and female black rockfish sampled from the Oregon recreational fishery (1990-2001). [ODF&W and RECFIN data]

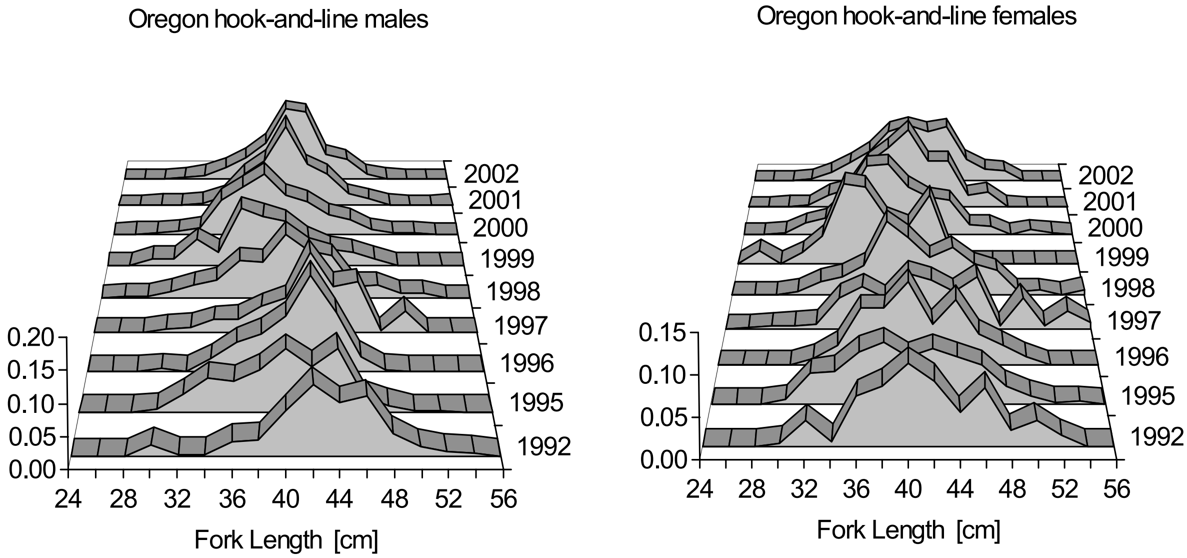


Figure 13. Length-frequency distributions for male and female black rockfish sampled from the Oregon commercial hook-and-line fishery (1992, 1995-2002).

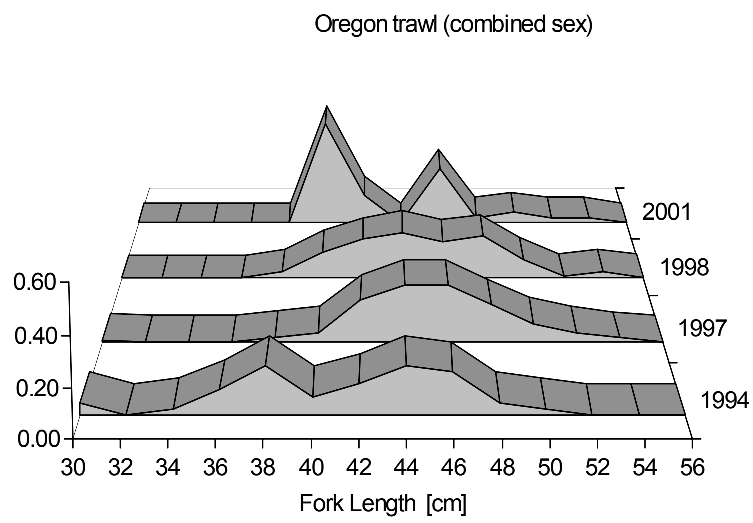


Figure 14. Length-frequency distributions for black rockfish sampled in the Oregon commercial trawl fishery (sexes combined).

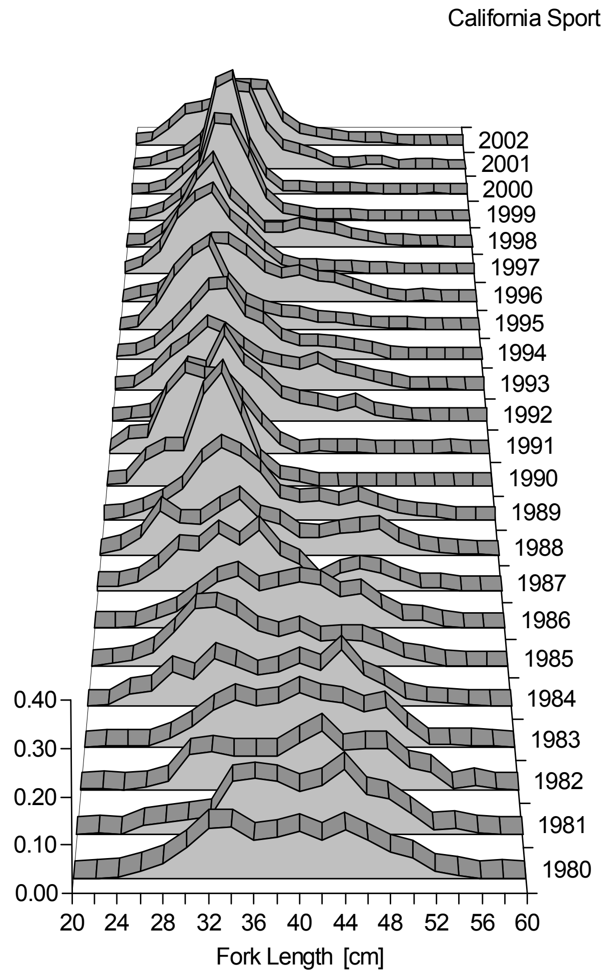


Figure 15. Combined-sex length-frequency distributions of black rockfish sampled in the California recreational fishery (1980-2002). [RECFIN and CDF&G data]

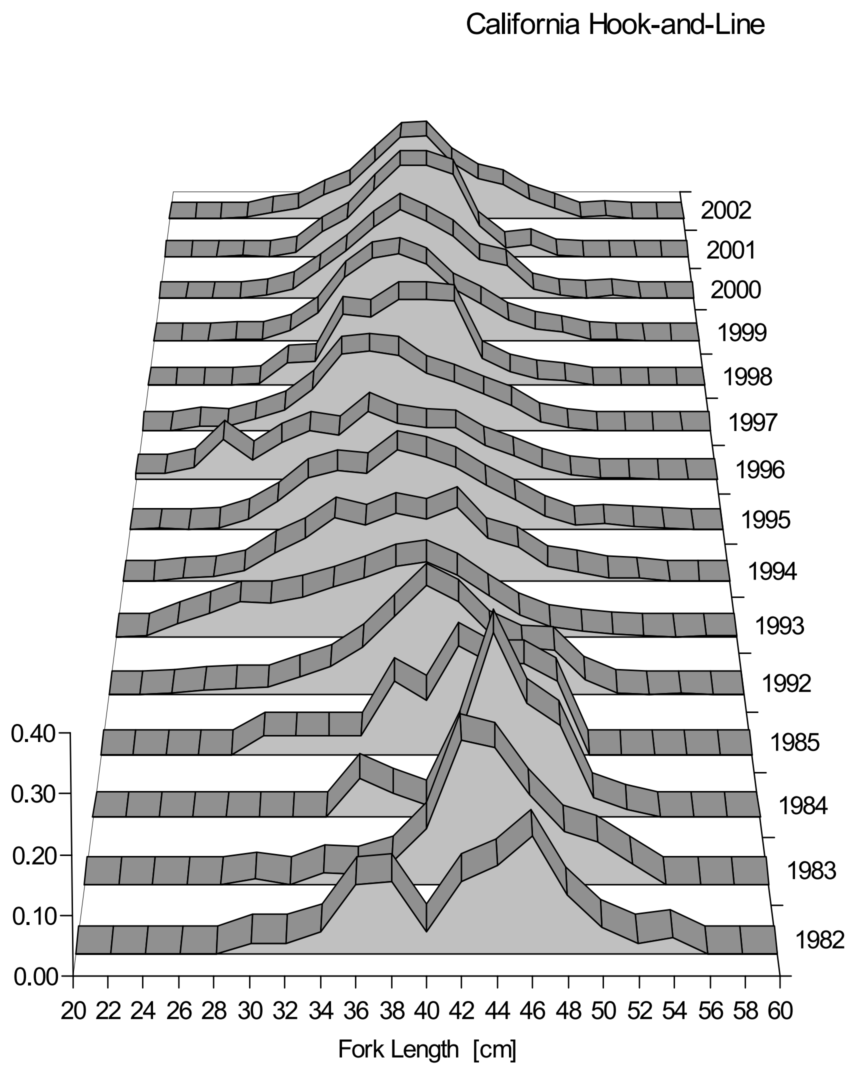


Figure 16. Combined-sex length-frequency distributions of black rockfish sampled in the California commercial hook-and-line fishery (1982-85, 1992-2002).

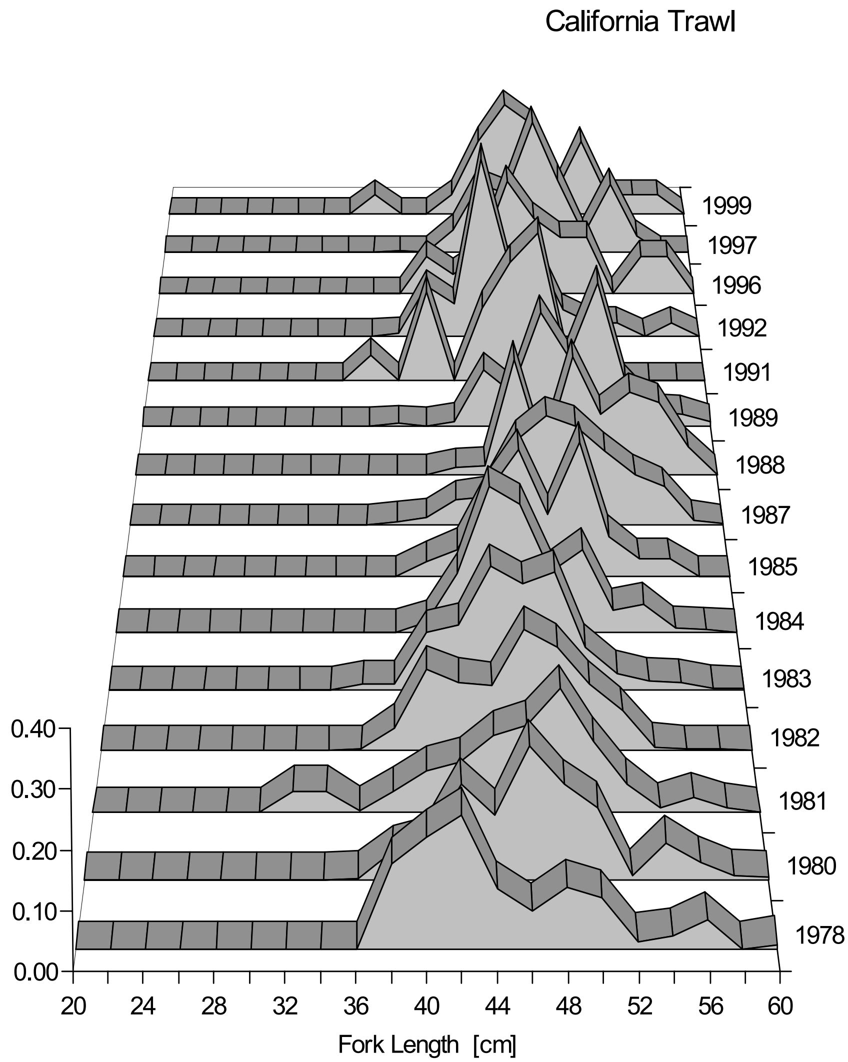


Figure 17. Combined-sex length-frequency distributions of black rockfish sampled in the California commercial trawl fishery (various years).

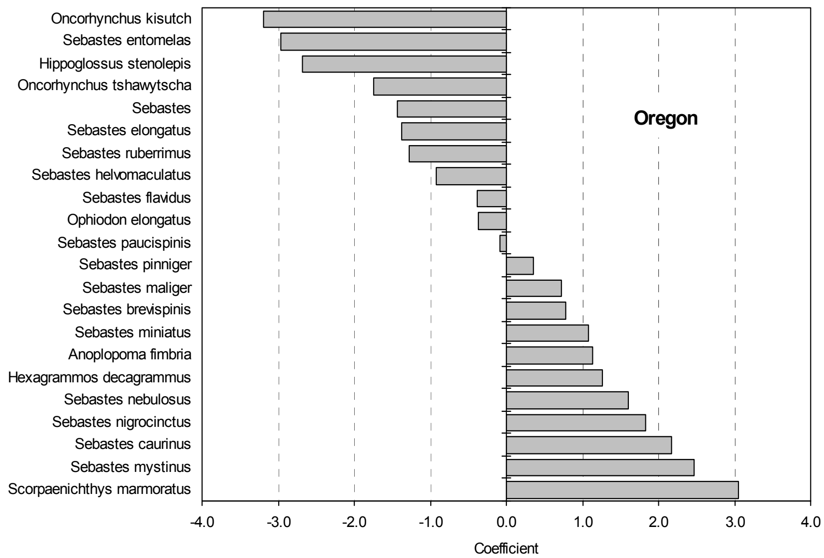


Figure 18. Species coefficients for presence of black rockfish in RECFIN trips conducted in Oregon.

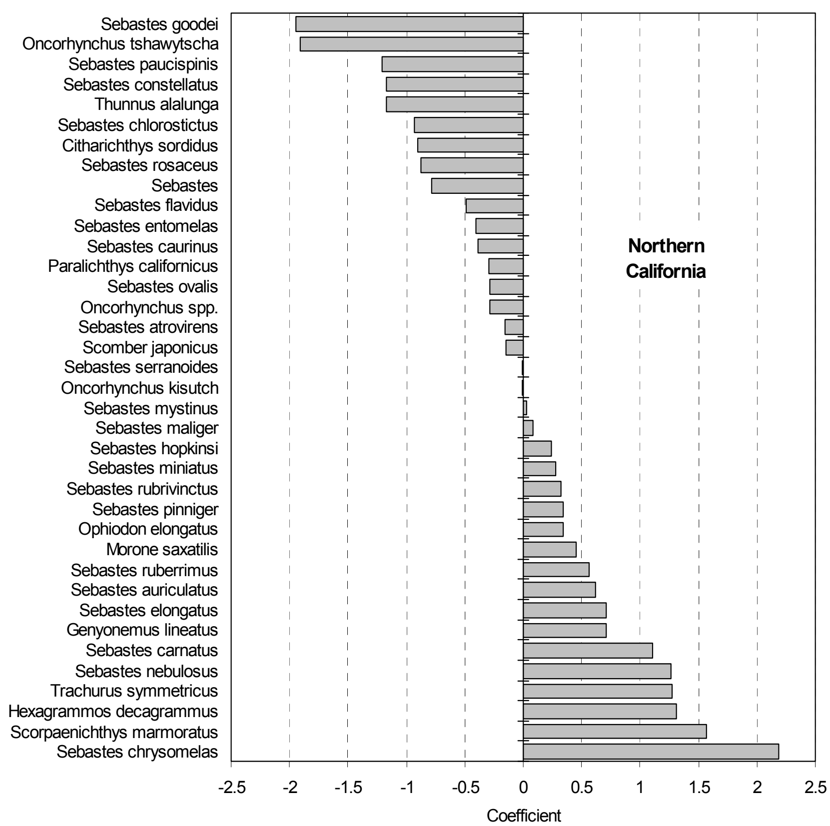


Figure 19. Species coefficients for the presence of black rockfish in RECFIN trips conducted in northern California.

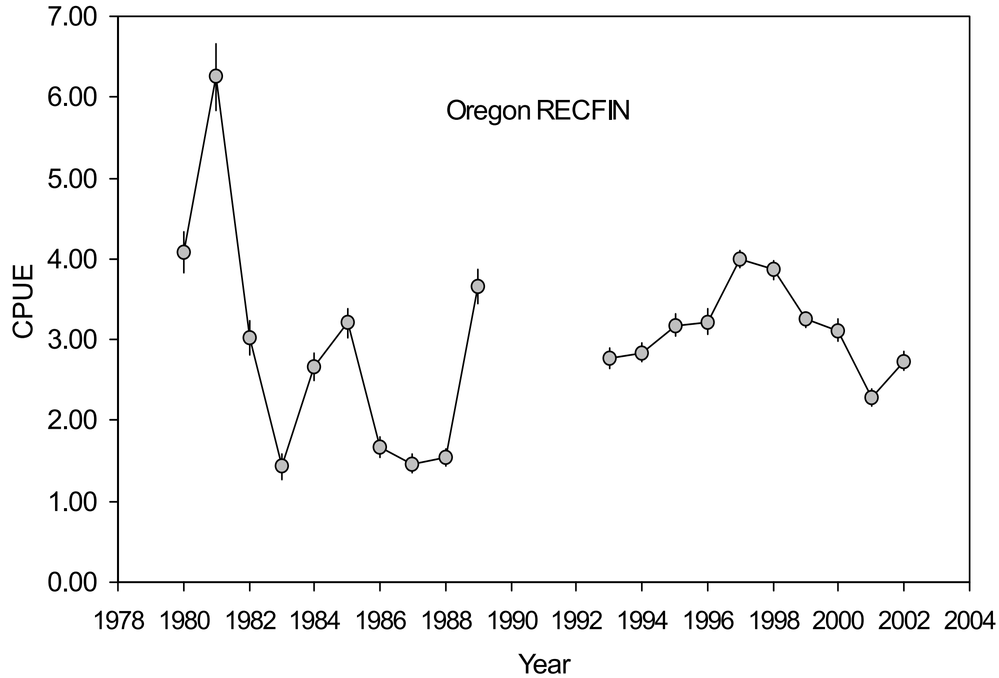


Figure 20. Time series of catch-per-unit effort in the Oregon recreational fishery based upon a weighted delta-gamma GLM analysis of RECFIN data. Error bars represent ± 1.0 standard error.

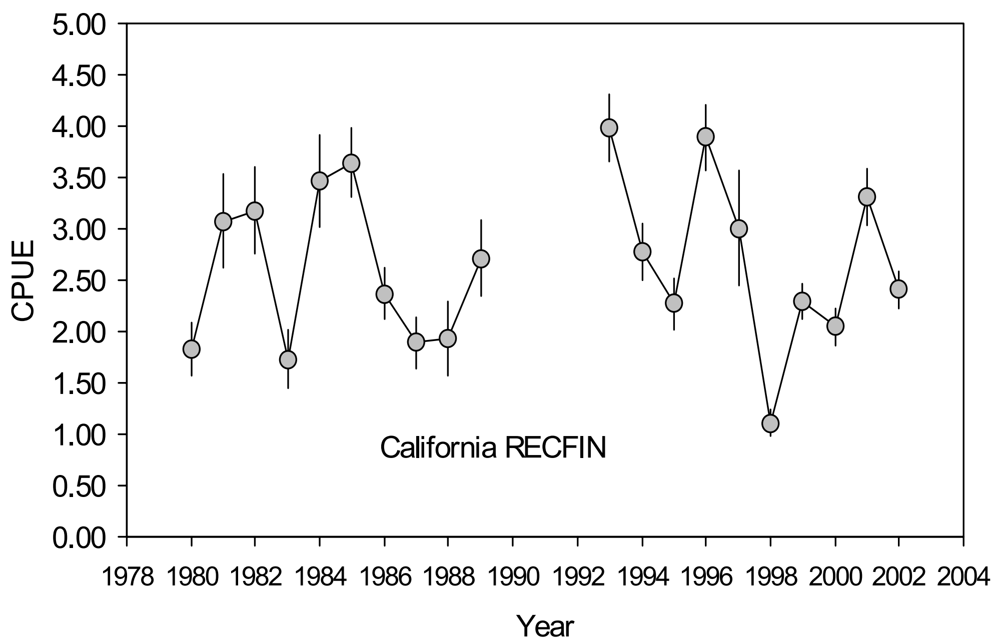


Figure 21. Time series of catch-per-unit-effort in the California recreational fishery based on a weighted delta-gamma GLM analysis of RECFIN data. Error bars represent ± 1.0 standard error.

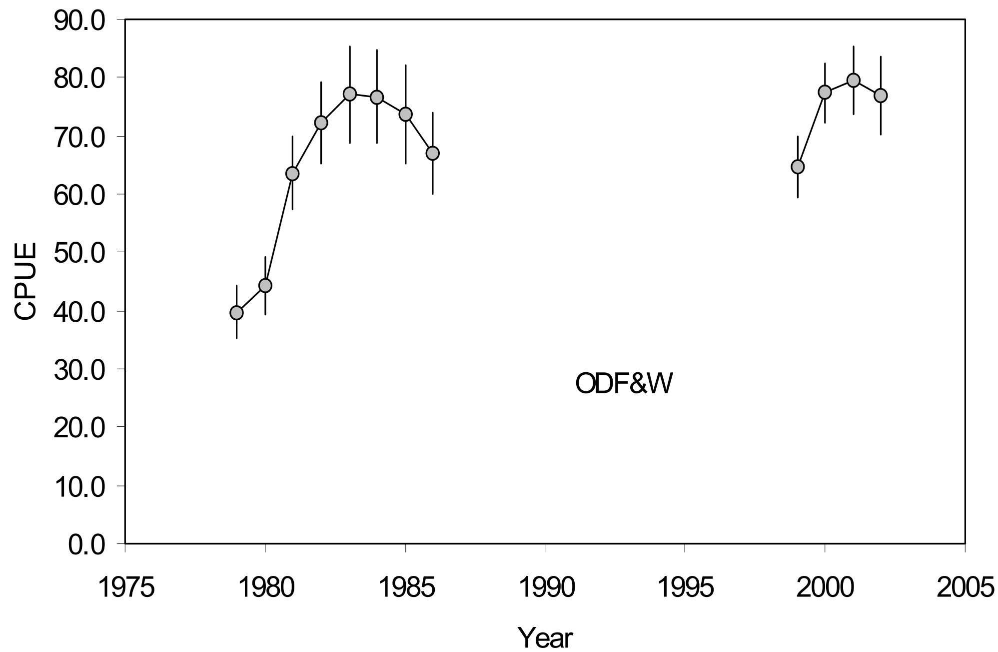


Figure 22. Time series of catch-per-unit-effort in the Oregon recreational fishery based on a 3-factor ANOVA model using ODF&W data. Error bars represent ± 1.0 standard error.

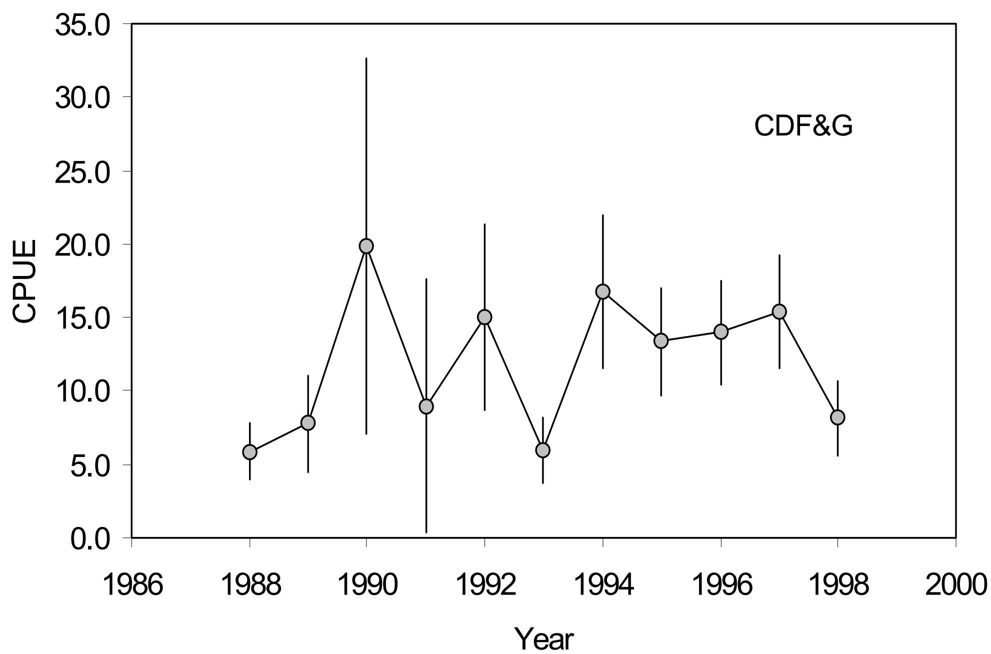


Figure 23. Time series of catch-per-unit effort in the California recreational fishery based on a delta-gamma GLM of CDF&G data. Error bars represent ± 1.0 standard error.

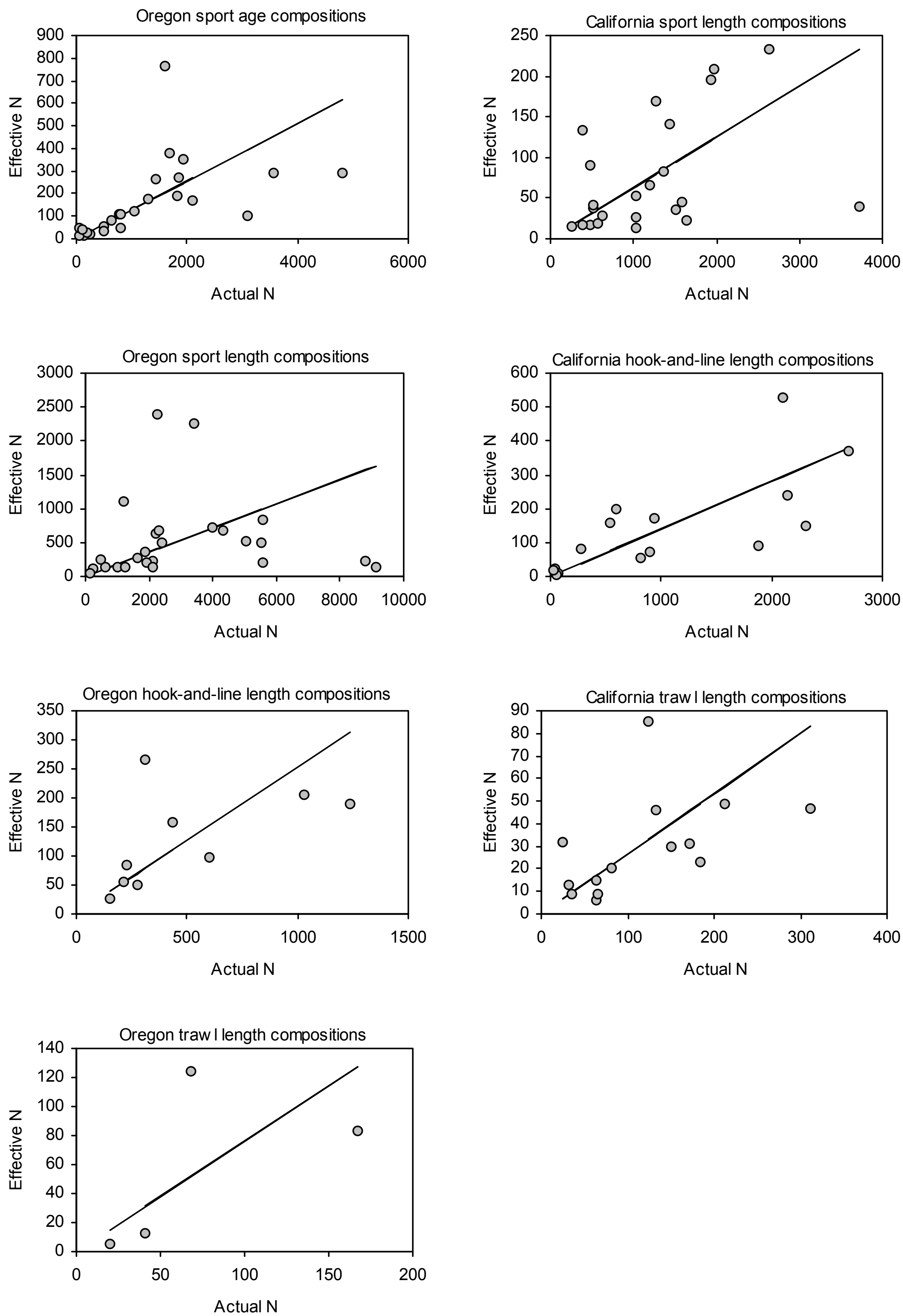


Figure 24. Relationship between the number of fish examined and the effective sample size for compositional data sets used in the assessment model.

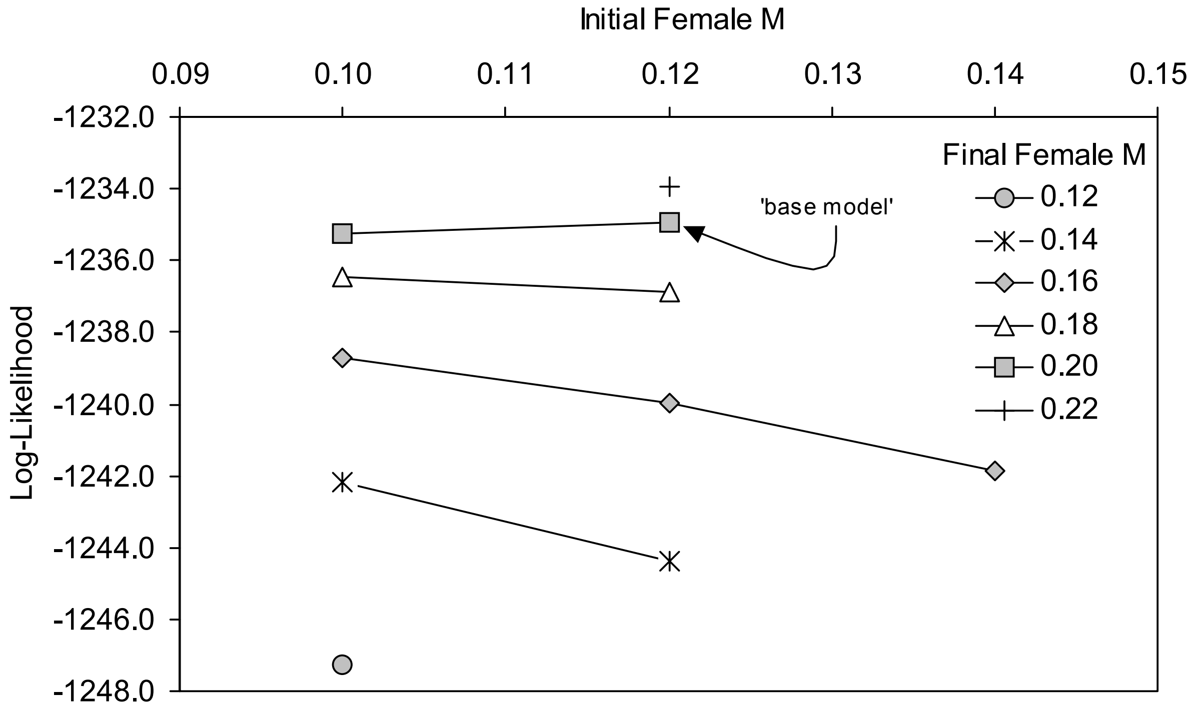


Figure 25. Likelihood profile of the fit of the data to the assessment model for different fixed values of initial and final female natural mortality rate (M [yr^{-1}]).

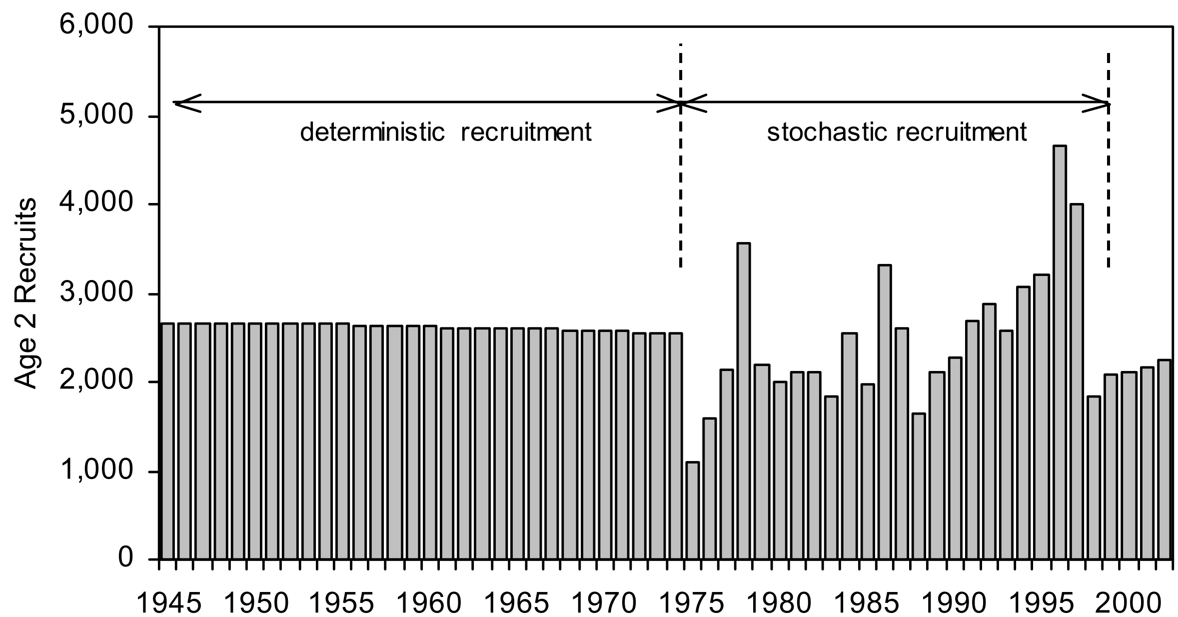


Figure 26. Time series of recruitments from the base assessment model.

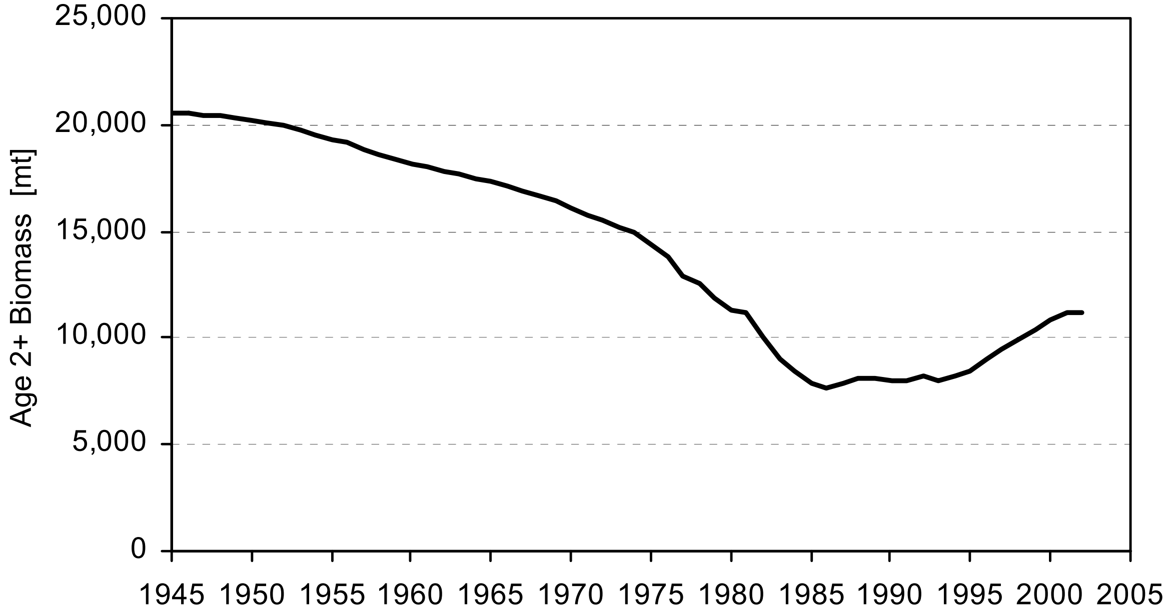


Figure 27. Estimated time series of age 2+ stock biomass from the base assessment model.

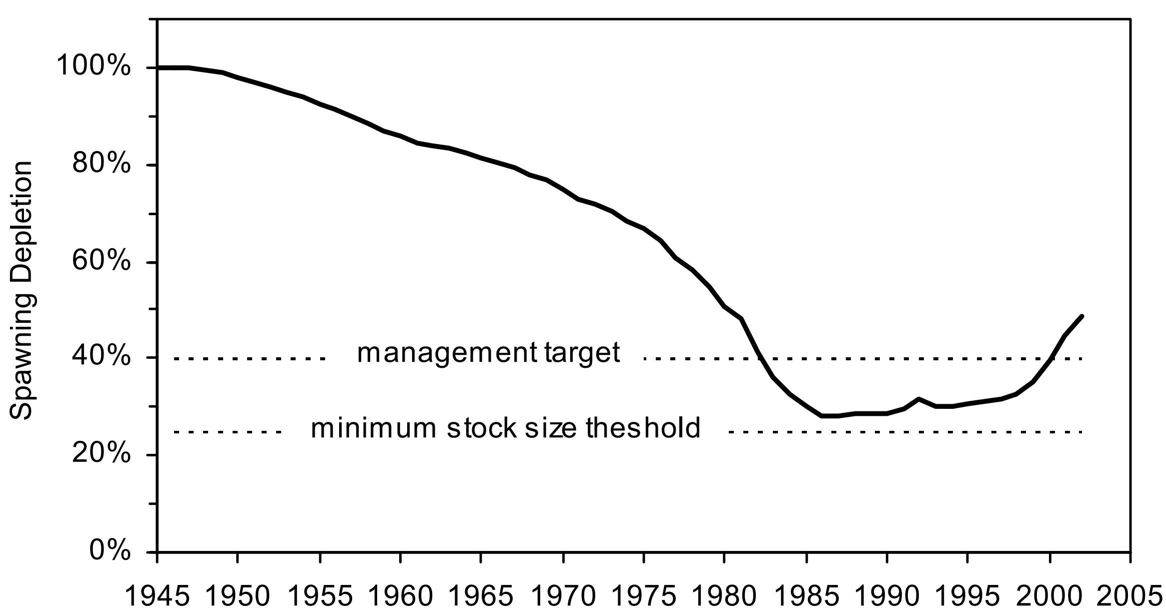


Figure 28. Estimated time series of spawning output of black rockfish relative to the unexploited state (=spawning depletion) from the base assessment model. The management target is 40% and the overfished minimum stock size threshold is 25%.

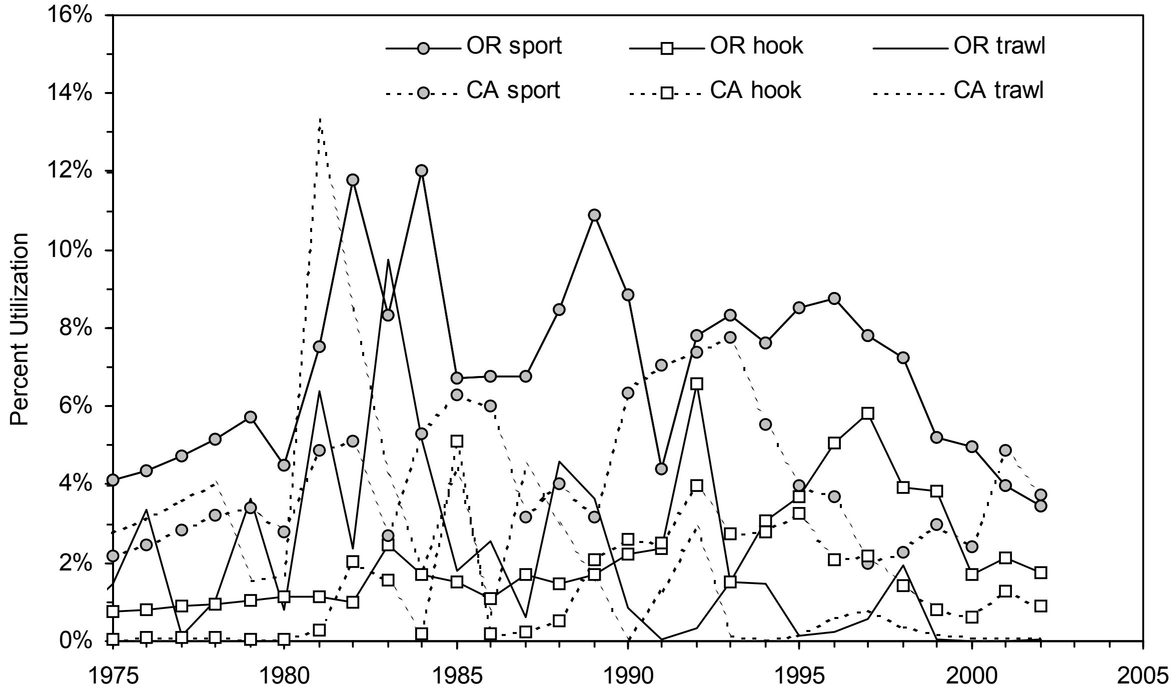


Figure 29. Time series of exploitation rate for each of the 6 modeled fisheries. Percent utilization is the catch divided by the fishery-specific exploitable biomass.

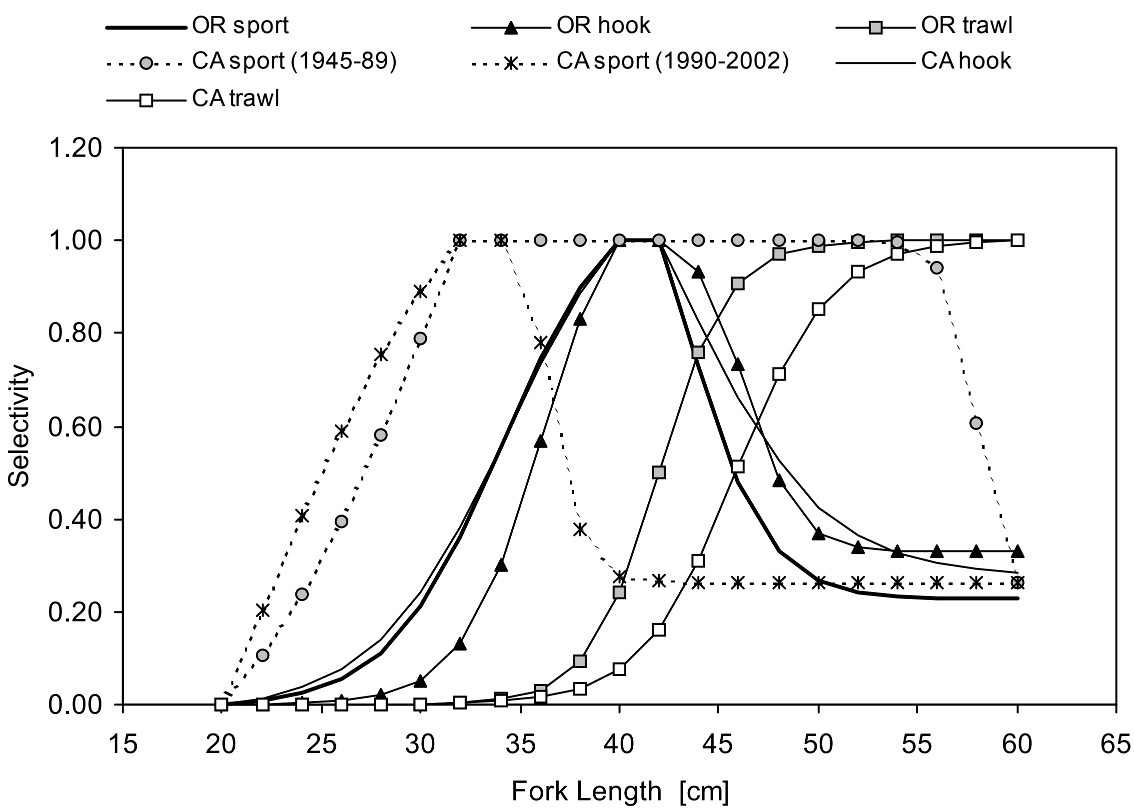


Figure 30. Fishery-specific selectivity curves from the base assessment model.

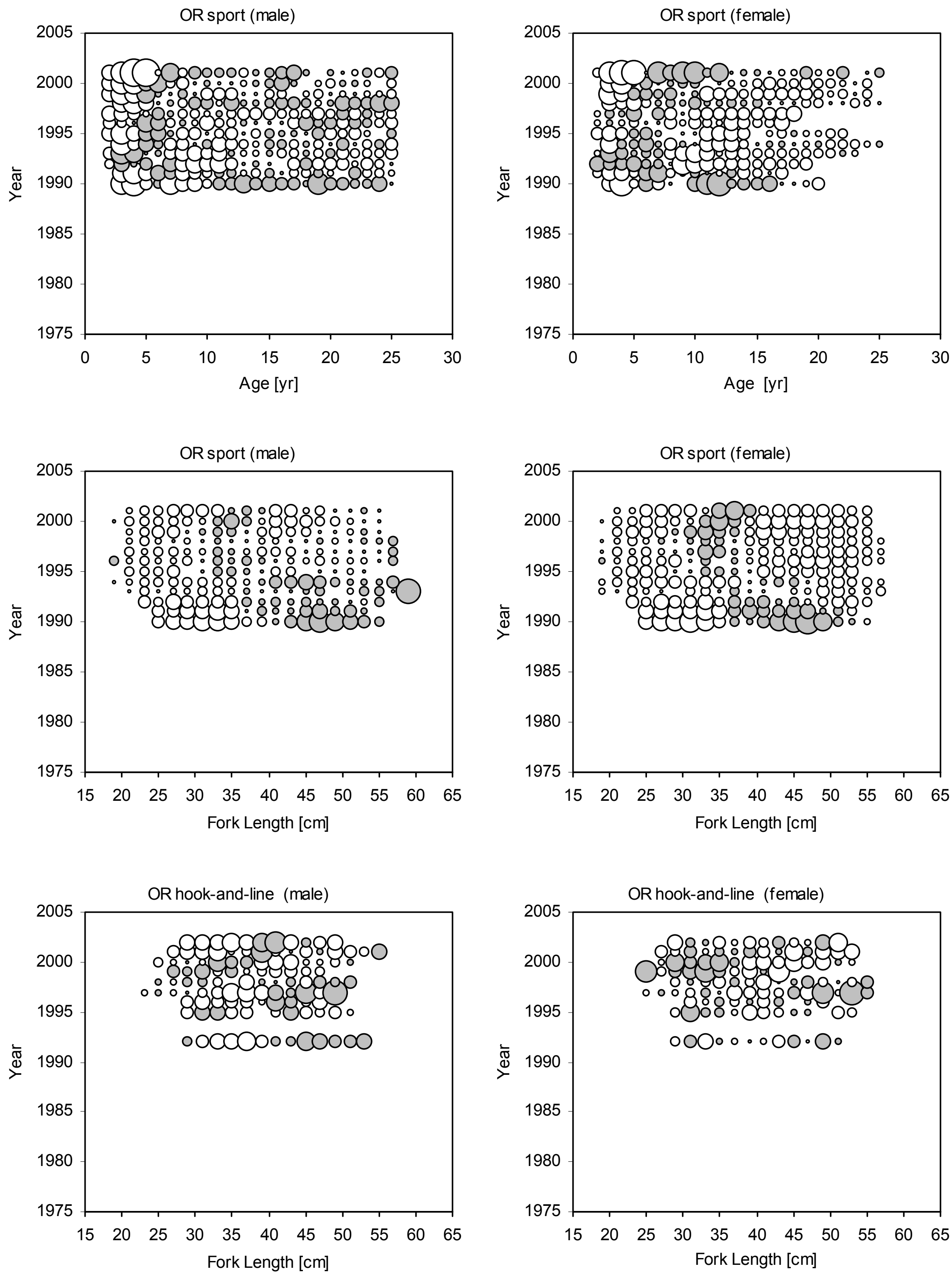


Figure 31. Fit of base stock assessment model to composition data from the Oregon recreational and hook-and-line fisheries. Filled circles are positive residuals (observed > expected), whereas open circles are negative residuals. Circle area is proportional to the normalized probability.

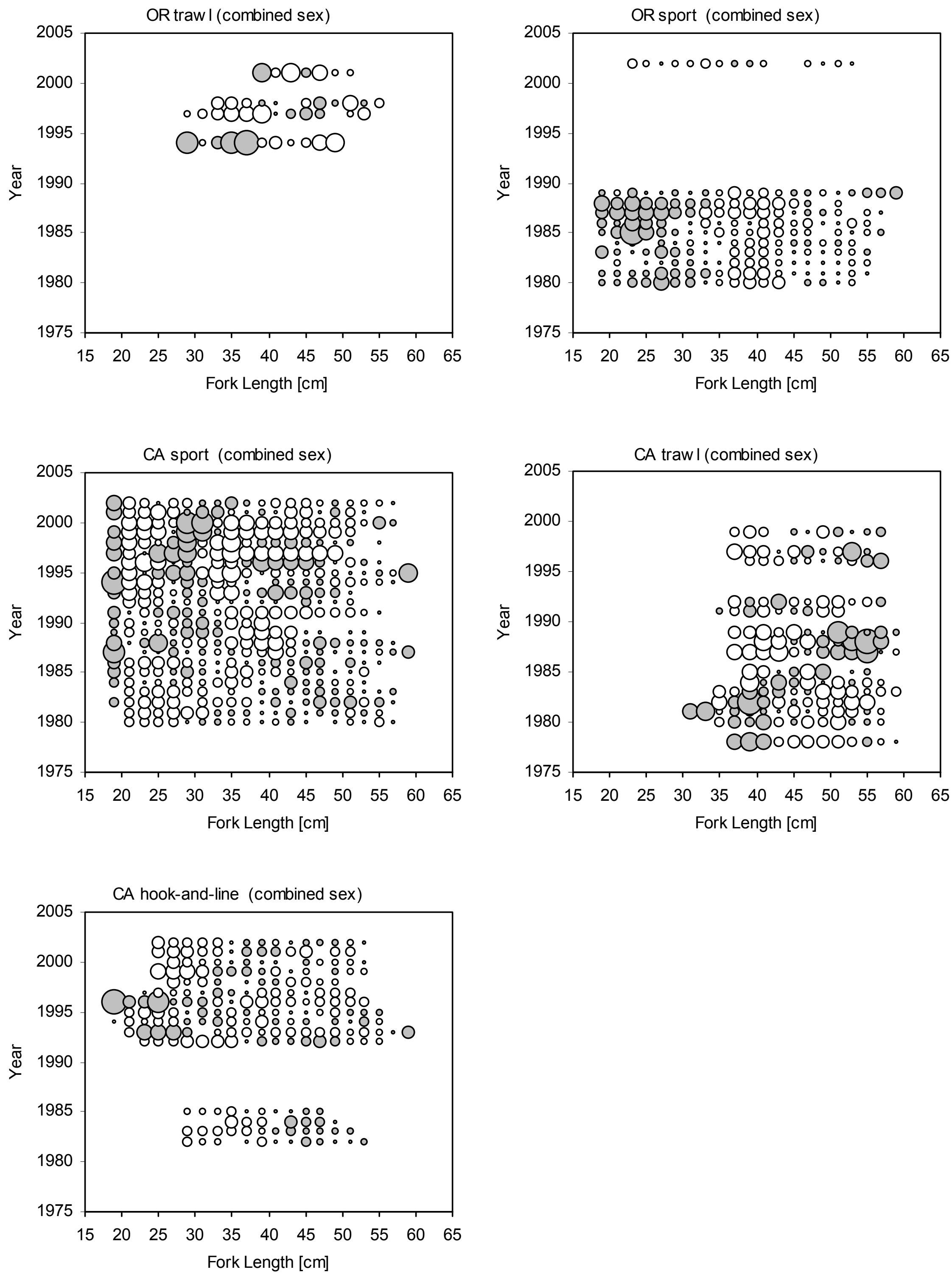


Figure 32. Fit of base stock assessment model to composition data from the Oregon trawl and California fisheries (recreational, hook-and-line, and trawl). Filled circles are positive residuals (observed > expected), whereas open circles are negative residuals. Circle area is proportional to the normalized probability.

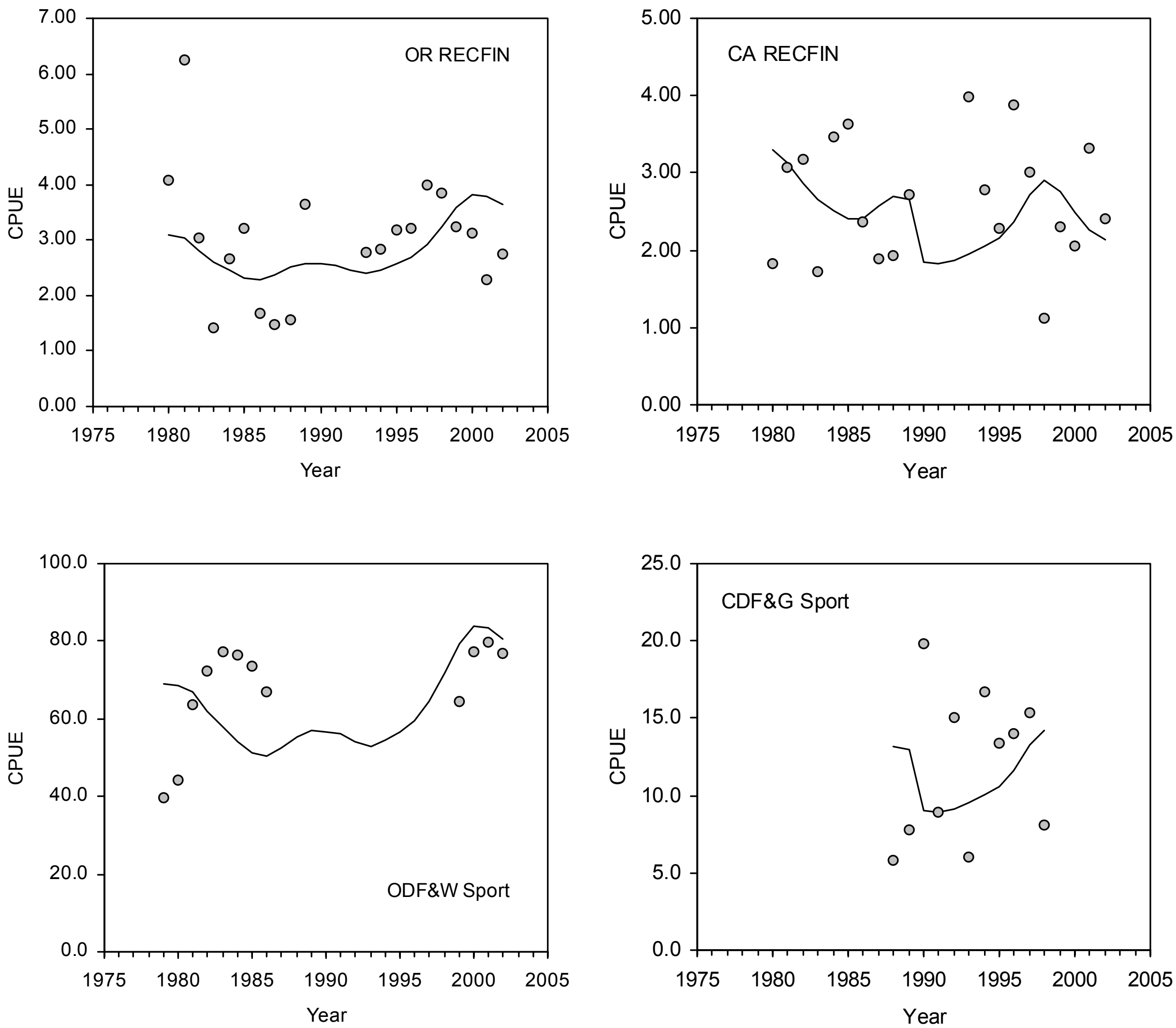


Figure 33. Fit of the base black rockfish stock assessment model to each of the four CPUE time series from recreational fisheries in Oregon and California.

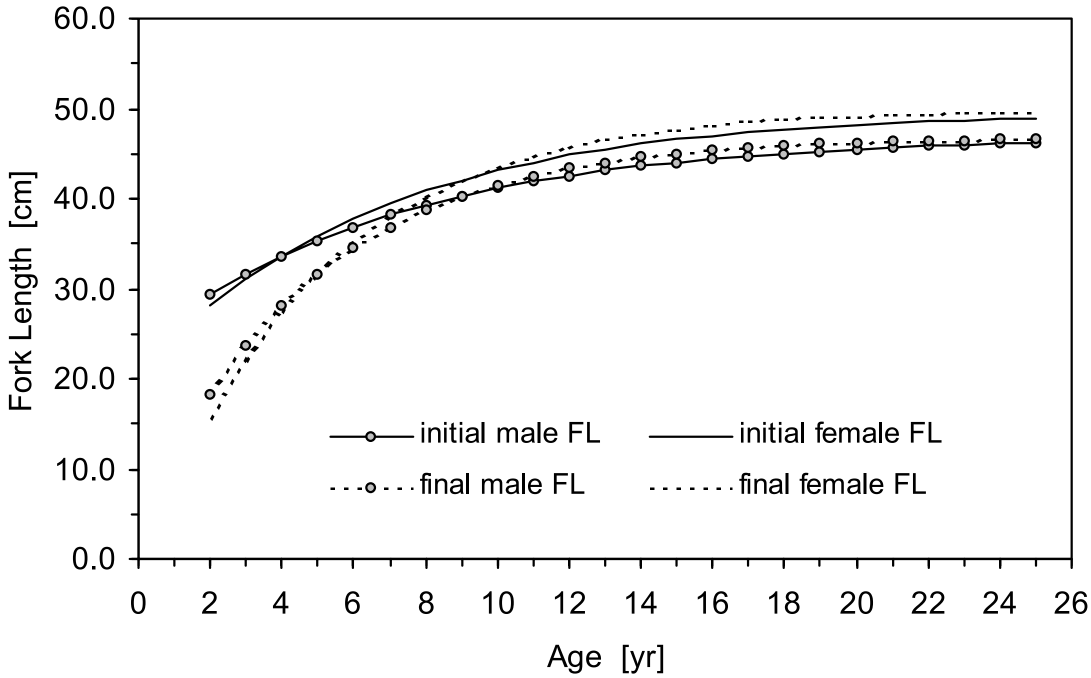


Figure 34. Estimated sex-specific growth of black rockfish from the stock assessment model (final) in comparison with initial estimates (see also Figure 2).

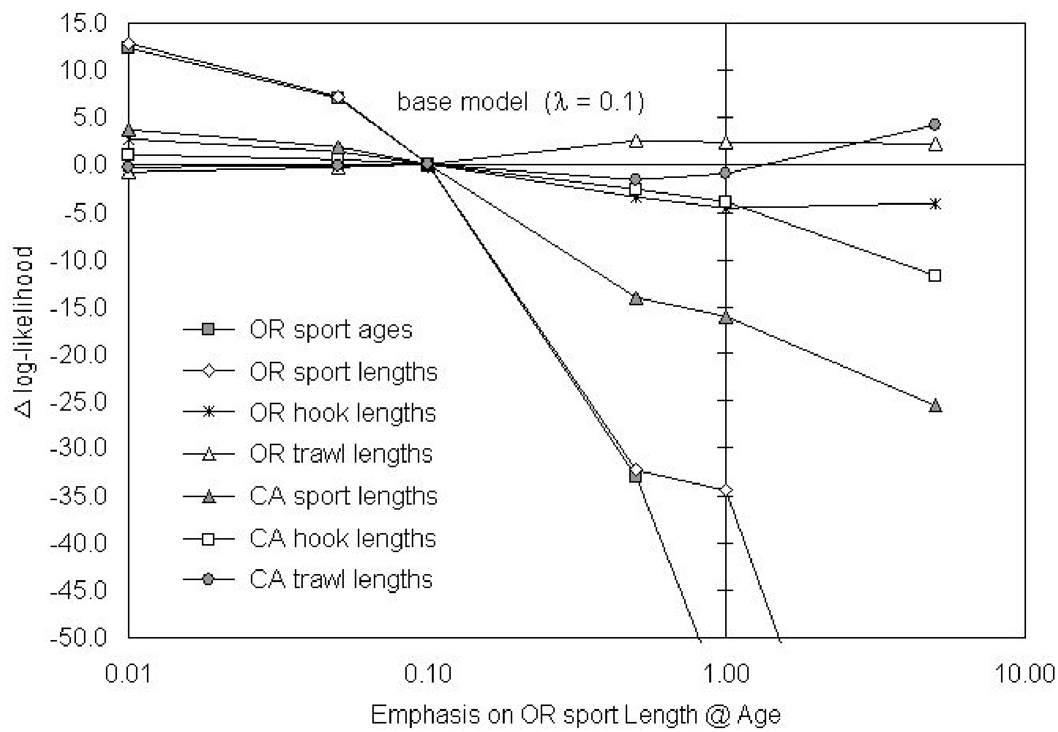


Figure 35. Likelihood profiles for the various components of the model following changes to the weight (emphasis) on the Oregon recreational length-at-age component.

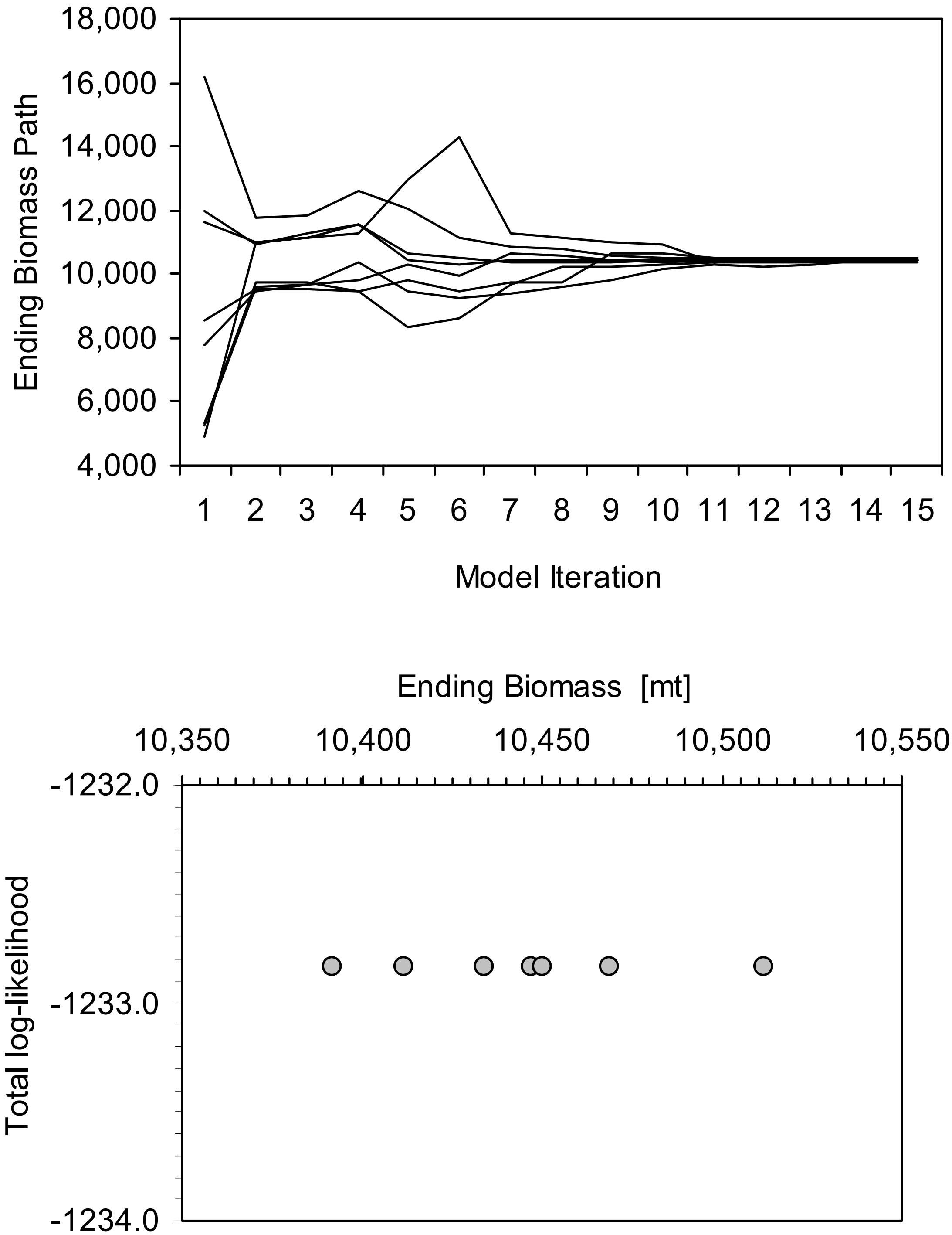


Figure 36. Convergence properties of the base black rockfish stock assessment model.

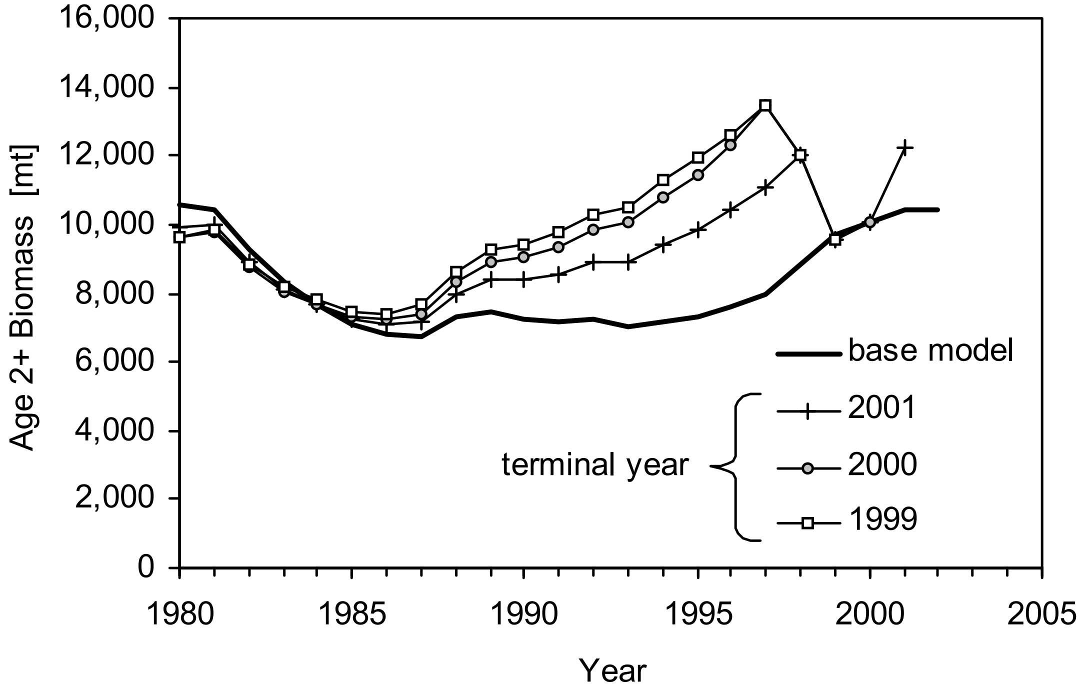


Figure 37. Retrospective analysis of the base black rockfish stock assessment model.

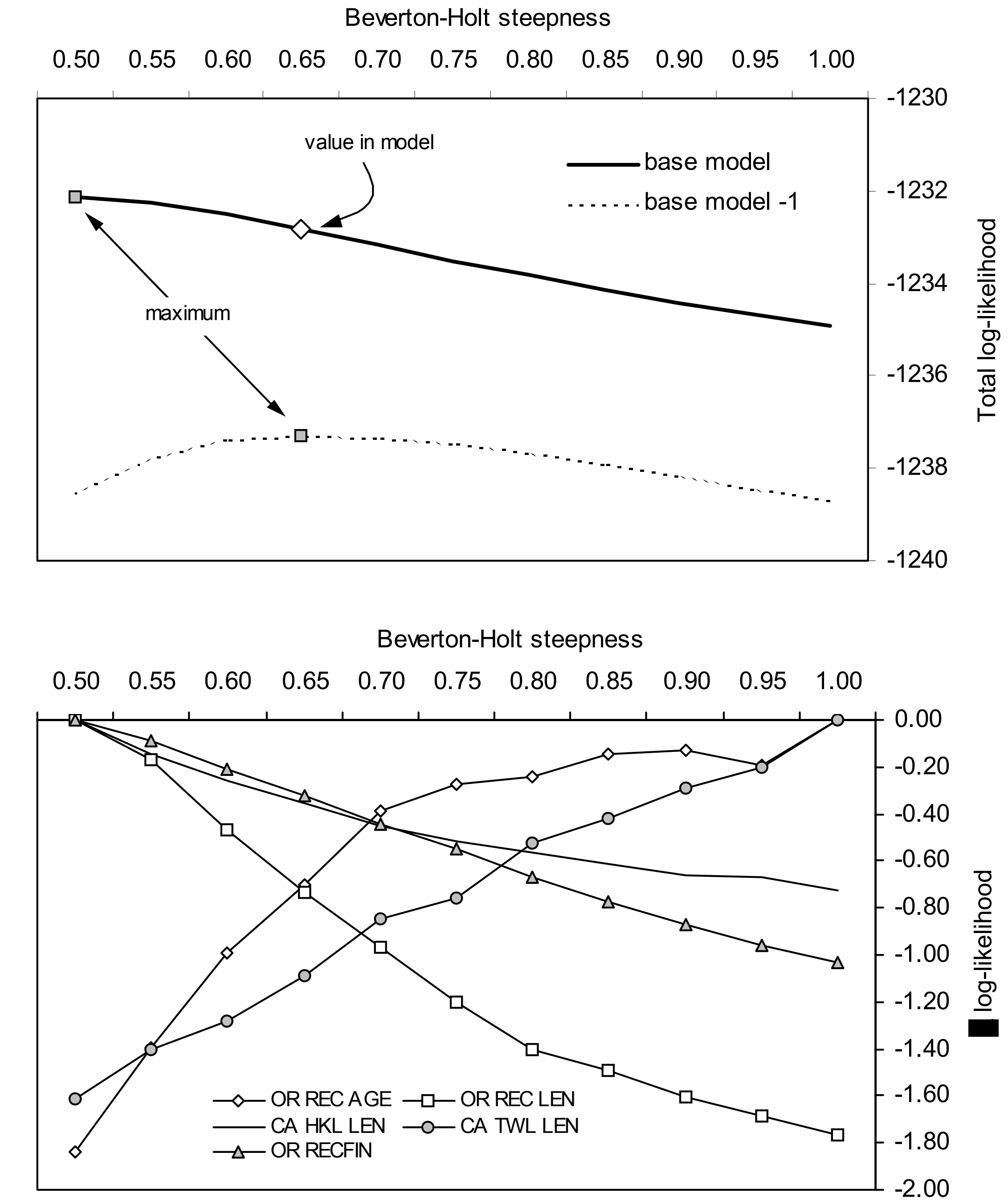


Figure 38. Upper Panel: Likelihood profile of the base assessment model for different fixed values of the Beverton-Holt steepness parameter (**h**). The final base model had steepness fixed at **h** = 0.65. Also shown is a similar profile for the penultimate version of the model (i.e., “base model - 1"). Lower Panel: changes in likelihood for certain components of the model over different fixed values of **h**.

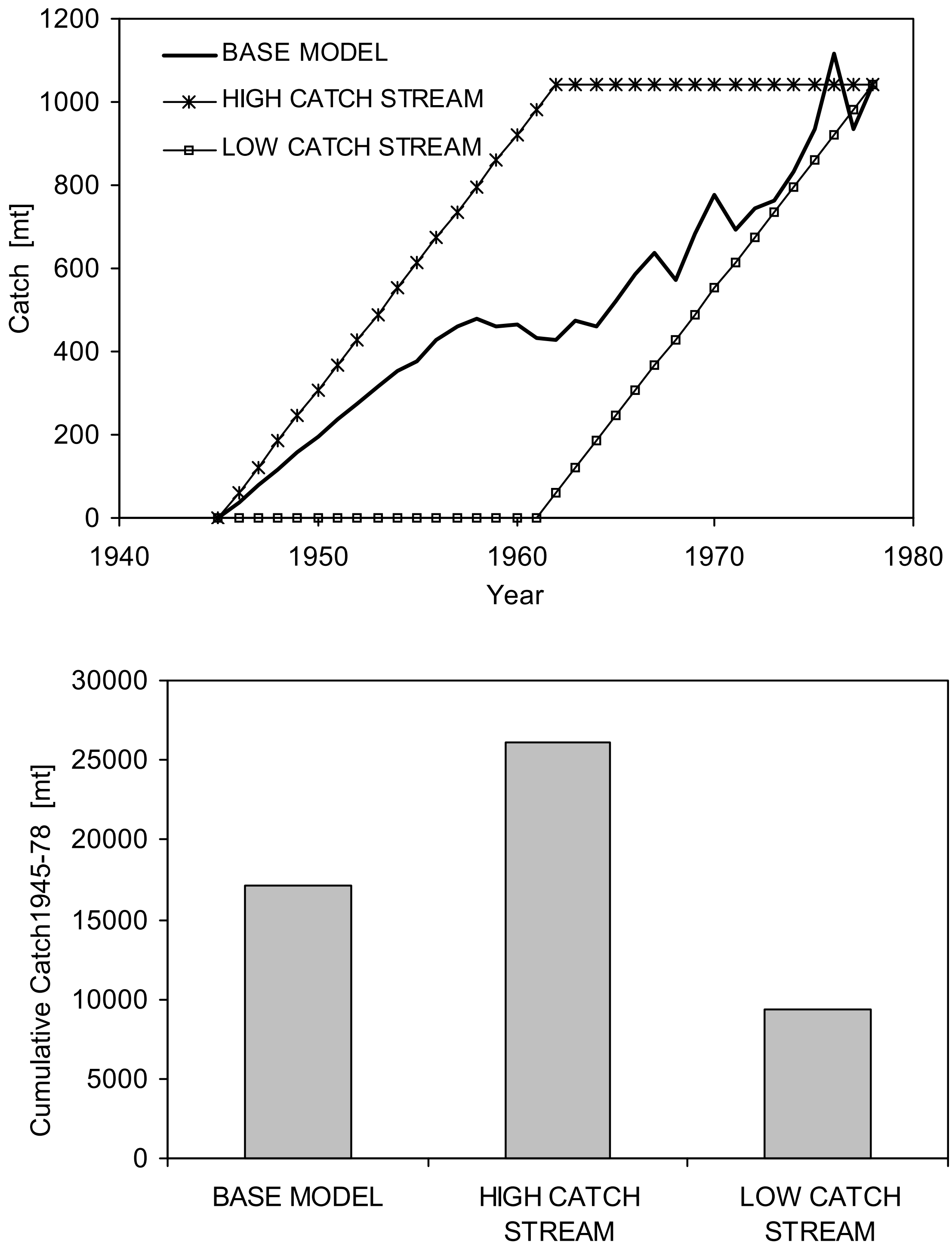


Figure 39. Uncertainty analysis of the effect of different historical catch streams on the base assessment model.

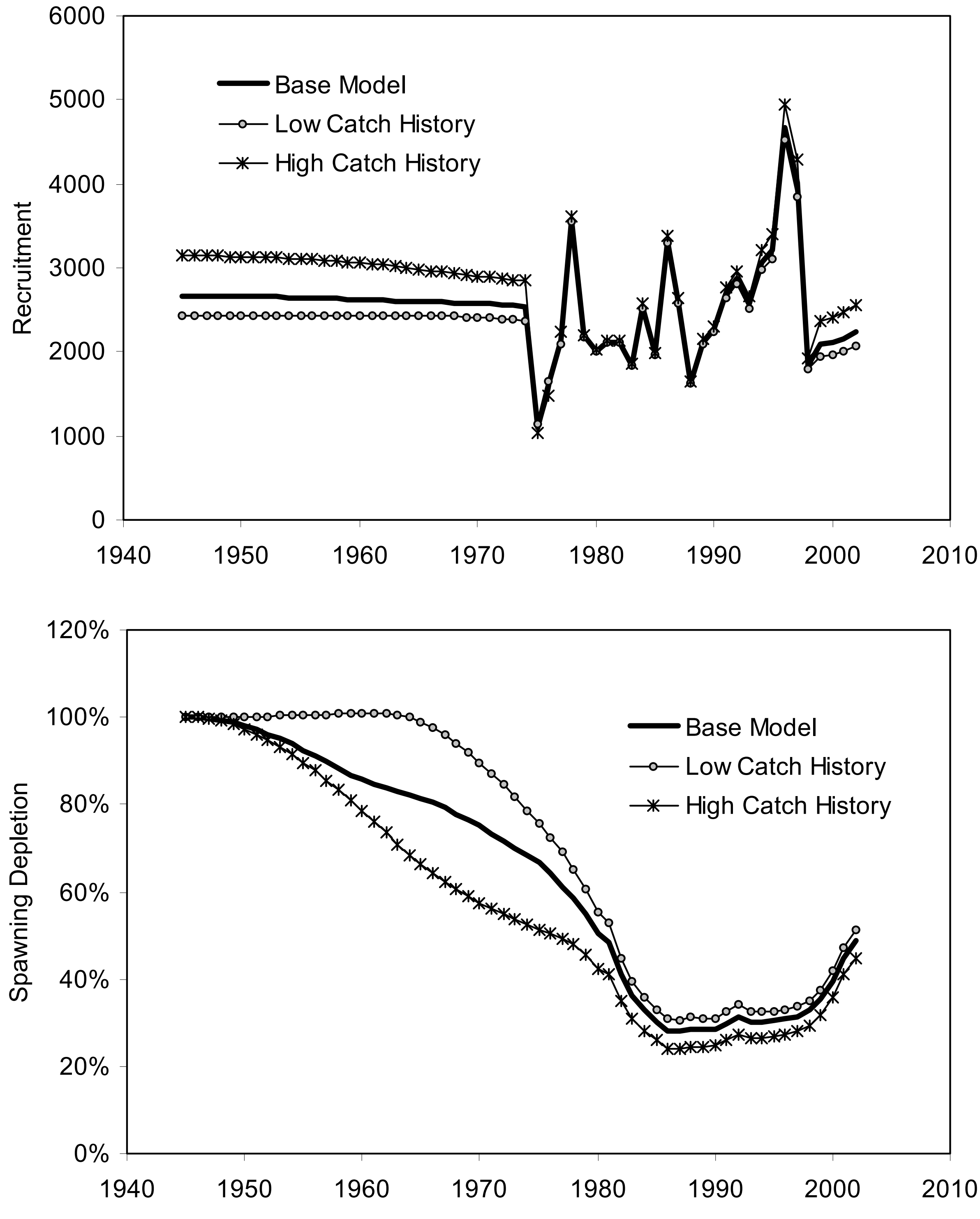


Figure 40. Model outputs under three different scenarios concerning the historical catch of black rockfish prior to 1978 (see Figures 38 & 39).

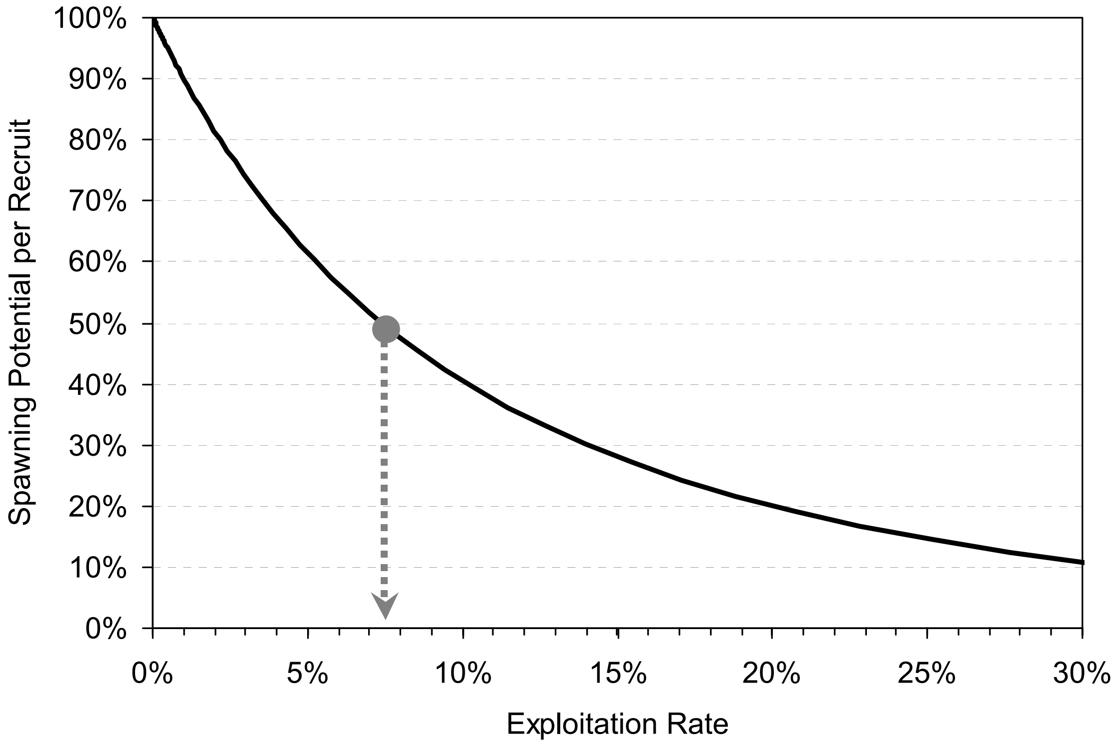


Figure 41. PFMC default harvest rate for *Sebastes* used in black rockfish projections (i.e., the exploitation rate that reduces the spawning potential per recruit to 50% of the unfished condition.

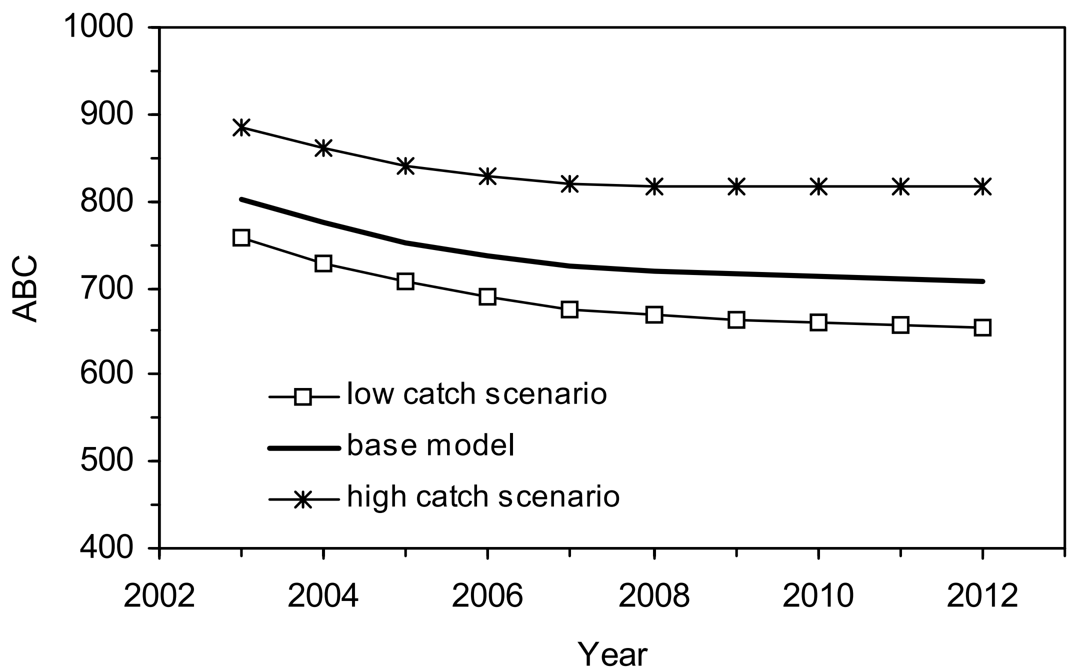


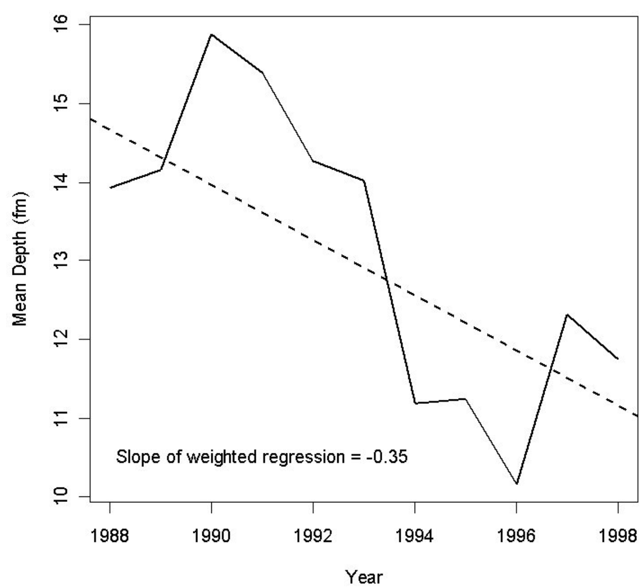
Figure 42. Variability in projected Allowable Biological Catches (ABCs) as a function of differences in historical catch.

Appendix 1: Evaluation of California recreational CPUE statistics based on data from the CDF&G Commercial Passenger Fishing Vessel survey

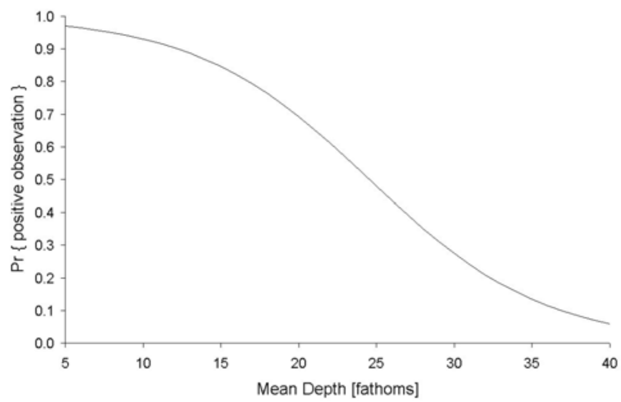
For the assessment, catch-per-unit-effort (CPUE) statistics of black rockfish were estimated for the California recreational fishery based on information from the RECFIN and CPFV data bases (see Figures 21 and 23). As suggested by the Stock Assessment Review (STAR) panel, a potential bias in CPUE can arise if the mean depth of fishing changes systematically over time and catch rates are depth-dependent. Therefore, the STAR panel requested the authors investigate: 1) trends in fishing depth over time, 2) the effect of depth on black rockfish catch rate, and 3) changes in mean fish length with depth. The only available information that can explicitly address these three issues is the CPFV data set, because fishing locations and depths are expressly included. The annual mean depth of central California CPFV trips was then modeled using a general linear model of the form:

$$\log_e(\text{depth}_{ijkl}) = \text{year}_i + \text{month}_j + \text{location}_k + \text{error term}_{ijkl}$$

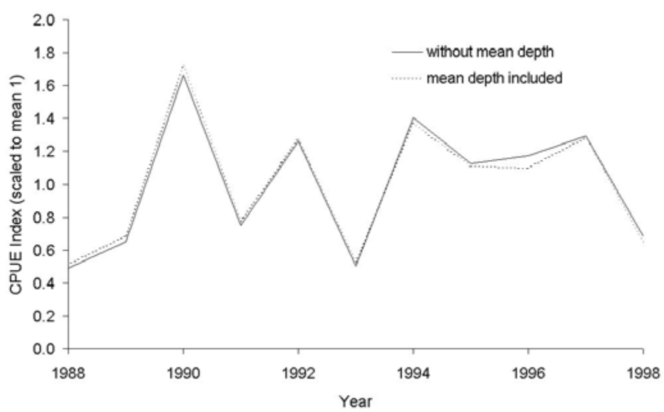
This model was selected by lowest AIC_c score. Moreover, this criterion provided no evidence of interaction among the three main effects. The first figure illustrates the trend in mean depth of CPFV trips, obtained by back-transformation and bias correction of year coefficients from the fitted model. A regression of mean depth versus year, weighted by the number of annual observations, suggests an average decrease in fishing depth of about 0.35 fathoms/yr.



To determine the effect of depth on catch rate, mean depth was added as a co-variate to the Generalized Linear Models (GLMs) used to calculate the delta-gamma index. Depth information was again obtained from the CPFV data set, which includes the minimum and maximum depths [fathom] at every location visited during sampled fishing trips. The second figure (below) illustrates the effect of mean fishing depth on the probability of 'observing' a positive CPUE (fitted values from the binomial GLM) while holding year, month, and location effects constant at their mean values. Analysis of deviance for the binomial GLM showed all main effect terms (year, month, location & mean depth) to be significant ($P < 0.01$, χ^2-test). A test of 2-way interactions showed no significant interaction between year and mean depth (P > 0.54). Mean depth was not significant in the gamma GLM (P > 0.25, F-test).



The results in these two figures suggest that fishing effort has shifted over time to depths characterized by higher catch rates. This effect would be expected to bias the CPUE statistic high over time, if mean depth were not included as a co-variate in the binomial model. The third figure, shown below, compares the delta-gamma index as it was calculated for the assessment (without mean depth), with the revised index that accounts for changes in mean depth via the binomial GLM. As expected, there is a slight bias in the original index, but the revised index does not substantially change the overall trend in CPUE for the CPFV fishery.



Attempts were made to identify changes in mean fish length over time, but most length information was processed shoreside, and it was often impossible to assign an accurate location to individual length measurements. This greatly reduced the sample size for data with accurate location information, of which only a small number met the criterion of a minimum of 5 black rockfish caught.

Appendix 2: Stock Synthesis parameter file for the base black rockfish stock assessment model

```
black03-new.txt   LOOP1:  7  LIKE: -1232.82899  DELTA LIKE:      .00023 ENDBIO:    10447.
black.run
black.par
FIRST MODEL:  "BASE" MODEL FROM 2001
     100.000000        .001000     BEGIN AND END DELTA F PER LOOP1
   3   .95               FIRST LOOP1 FOR LAMBDA & VALUE
   1.200                 MAX VALUE FOR CROSS DERIVATIVE
   1 READ HESSIAN
black.hes
   1 WRITE HESSIAN
black.hes
    .000                 MIN SAMPLE FRAC. PER AGE
   2  25   4  25         MINAGE, MAXAGE,  SUMMARY AGE RANGE
  1945  2002             BEGIN YEAR, END YEAR
  1      12  0  0  0     NPER, MON/PER
  1.00                   SPAWNMONTH
  6  4 NFISHERY, NSURVEY
  2 N SEXES
   10000.  REF RECR LEVEL
  3 MORTOPT
     .120000     .010000    1.000000 'M-FEMALE-YOUNG  '   0     1  0     .000000   .0000 !   1 NO PICK    .000        0.       .0000000
     .200000     .010000    1.000000 'M-FEMALE-OLD    '   0     1  0     .000000   .0000 !   2 NO PICK    .000        0.       .0000000
   10.000000    4.000000   18.000000 'M-FEMALE-INFLECT'   0     1  0     .000000   .0000 !   3 NO PICK    .000        0.       .0000000
     .120000     .010000    1.000000 'M-MALE-YOUNG    '   0     1  0     .000000   .0000 !   4 NO PICK    .000        0.       .0000000
     .120000     .010000    1.000000 'M-MALE-OLD      '   0     1  0     .000000   .0000 !   5 NO PICK    .000        0.       .0000000
    1.000000    4.000000   18.000000 'M-MALE-INFLECT  '   0     1  0     .000000   .0000 !   6 NO PICK    .000        0.       .0000000
 OR SPORT   TYPE:  1
  7 SELECTIVITY PATTERN
   0   2   0   3   4   0   0  AGE TYPES USED
     1.00000       .02 'OR REC CATCHES      '  ! # =  1 VALUE:         .00000
     1.00000       .30 'OR REC AGE COMPS    '  ! # =  2 VALUE:     -169.89859
     1.00000       .30 'OR REC LEN COMPS    '  ! # =  3 VALUE:     -345.09100
      .10000     -1.00 'OR REC LEN@AGE      '  ! # =  4 VALUE:    -2177.15867
  2  2  0  0  0  0  SEL. COMPONENTS
   39.000000   20.000000   55.000000 'Transition lengt'   0     1  0     .000000   .0000 !   7 NO PICK    .000        0.       .0000000
     .001000     .000010    1.000000 'Min size selecti'   0     1  0     .000000   .0000 !   8 NO PICK    .000        0.       .0000000
     .670917     .050000     .950000 'Size@ascend infl'   2     1  0     .000000   .0000 !   9 OK         .000   -29763.       .0001782
     .355588     .010000    4.000000 'Ascending slope '   2     1  0     .000000   .0000 !  10 OK         .000   -19307.       .0001332
     .228483     .001000     .990000 'F-max size selec'   2     1  0     .000000   .0000 !  11 OK         .000    -3684.       .0010530
     .050000     .050000     .850000 'F-descend inflec'   2     1  0     .000000   .0000 !  12 BOUND      .000        0.       .0000000
     .524694     .010000    5.000000 'F-descend slope '   2     1  0     .000000   .0000 !  13 OK         .000     -869.       .0063543
 OR HOOK    TYPE:  2
  7 SELECTIVITY PATTERN
   0   0   0   6   0   0   0  AGE TYPES USED
     1.00000       .02 'OR HOOK CATCHES     '  ! # =  5 VALUE:         .00000
     1.00000       .30 'OR HOOK LEN COMPS   '  ! # =  6 VALUE:      -90.76399
  2  2  0  0  0  0  SEL. COMPONENTS
   39.000000   20.000000   55.000000 'Transition lengt'   0     1  0     .000000   .0000 !  14 NO PICK    .000        0.       .0000000
     .001000     .000000    1.000000 'Min size selecti'   0     1  0     .000000   .0000 !  15 NO PICK    .000        0.       .0000000
     .775690     .050000    2.000000 'Size@ascend infl'   2     1  0     .000000   .0000 !  16 OK         .000    -3701.       .0008169
     .511292     .010000    4.000000 'Ascending slope '   2     1  0     .000000   .0000 !  17 OK         .000    -1380.       .0018067
     .331768     .001000     .990000 'F-max size selec'   2     1  0     .000000   .0000 !  18 OK         .000     -263.       .0102456
     .276182     .050000     .850000 'F-descend inflec'   2     1  0     .000000   .0000 !  19 OK         .000     -870.       .0018683
     .799760     .010000    5.000000 'F-descend slope '   2     1  0     .000000   .0000 !  20 OK         .001      -10.       .2039244
 OR TRAWL   TYPE:  3
  7 SELECTIVITY PATTERN
   0   0   0   8   0   0   0  AGE TYPES USED
     1.00000       .02 'OR TRAWL CATCHES    '  ! # =  7 VALUE:         .00000
     1.00000       .30 'OR TRAWL LEN COMPS  '  ! # =  8 VALUE:      -35.35911
  2  0  0  0  0  0  SEL. COMPONENTS
     .001000     .000000    1.000000 'Min size selecti'   0     1  0     .000000   .0000 !  21 NO PICK    .000        0.       .0000000
     .540660     .050000     .950000 'Size@ascend infl'   2     1  0     .000000   .0000 !  22 OK         .000   -14688.       .0001283
     .574077     .010000   20.000000 'Ascending slope '   2     1  0     .000000   .0000 !  23 OK         .000     -363.       .0048393
 CA SPORT   TYPE:  4
  7 SELECTIVITY PATTERN
   0   0   0  10   0   0   0  AGE TYPES USED
     1.00000       .02 'CA REC CATCHES      '  ! # =  9 VALUE:         .00000
     1.00000       .30 'CA REC LEN COMPS    '  ! # = 10 VALUE:     -179.51464
  2  2  0  0  0  0  SEL. COMPONENTS
   31.000000   20.000000   55.000000 'Transition lengt'   0     1  0     .000000   .0000 !  24 NO PICK    .000        0.       .0000000
     .001000     .000010    1.000000 'Min size selecti'   0     1  0     .000000   .0000 !  25 NO PICK    .000        0.       .0000000
     .100000     .050000     .950000 'Size@ascend infl'   0     1  1     .000000   .0000 !  26 ENV FXN    .000        0.       .0000000
     .175686     .010000    4.000000 'Ascending slope '   2     1  0     .000000   .0000 !  27 OK         .000    -1114.       .0010716
     .264572     .001000     .990000 'F-max size selec'   2     1  0     .000000   .0000 !  28 OK         .000    -2041.       .0010021
     .050000     .050000     .850000 'F-descend inflec'   0     1  2     .000000   .0000 !  29 ENV FXN    .000        0.       .0000000
    1.237727     .010000    8.000000 'F-descend slope '   2     1  0     .000000   .0000 !  30 OK         .001      -15.       .0735644
 CA HOOK    TYPE:  5
  7 SELECTIVITY PATTERN
   0   0   0  12   0   0   0  AGE TYPES USED
     1.00000       .02 'CA HOOK CATCHES     '  ! # = 11 VALUE:         .00000
     1.00000       .30 'CA HOOK LEN COMPS   '  ! # = 12 VALUE:     -124.34002
  2  2  0  0  0  0  SEL. COMPONENTS
   39.000000   20.000000   55.000000 'Transition lengt'   0     1  0     .000000   .0000 !  31 NO PICK    .000        0.       .0000000
     .001000     .000000    1.000000 'Min size selecti'   0     1  0     .000000   .0000 !  32 NO PICK    .000        0.       .0000000
     .686058     .050000    2.000000 'Size@ascend infl'   2     1  0     .000000   .0000 !  33 OK         .000    -4167.       .0017849
     .301537     .010000    4.000000 'Ascending slope '   2     1  0     .000000   .0000 !  34 OK         .000    -5968.       .0007864
     .284097     .001000     .990000 'F-max size selec'   2     1  0     .000000   .0000 !  35 OK         .000     -331.       .0057804
     .050000     .050000     .850000 'F-descend inflec'   2     1  0     .000000   .0000 !  36 BOUND      .000        0.       .0000000
     .301790     .010000    5.000000 'F-descend slope '   2     1  0     .000000   .0000 !  37 OK         .000     -417.       .0054991
 CA TRAWL   TYPE:  6
  7 SELECTIVITY PATTERN
   0   0   0  14   0   0   0  AGE TYPES USED
     1.00000       .02 'CA TRAWL CATCHES    '  ! # = 13 VALUE:         .00000
     1.00000       .30 'CA TRAWL LEN COMPS  '  ! # = 14 VALUE:     -101.46734
  2  0  0  0  0  0  SEL. COMPONENTS
     .001000     .000000    1.000000 'Min size selecti'   0     1  0     .000000   .0000 !  38 NO PICK    .000        0.       .0000000
     .622229     .050000     .950000 'Size@ascend infl'   2     1  0     .000000   .0000 !  39 OK         .000   -12890.       .0002254
     .425514     .010000   20.000000 'Ascending slope '   2     1  0     .000000   .0000 !  40 OK         .000    -2290.       .0010778
```

```
OR RECFI   TYPE:  7
 2 SELECTIVITY PATTERN
  0   0   0   0   0   0   0  AGE TYPES USED
    .000561 -1  1  2 Q, QUANT, LOGERROR=1, BIO=1 or NUM=2
    .000561     .000100  100.000000 'OR-REC CPUE Q    '   2     1  0     .000000   .0000 !  41 OK          .000*********       .0000000
    .000000   -1.000000     .000000 'OR-REC CPUE bioQ'   0     1  0     .000000   .0000 !  42 NO PICK     .000        0.      .0000000
   1.00000       .37 'OREGON RECFIN CPUE  '  ! # = 15 VALUE:       11.11111
   1.000000     .001000   40.000000 'USE SELEX FROM 1'   0     1  0     .000000   .0000 !  43 NO PICK     .000        0.      .0000000
  19.000000     .050000   99.000000 'MIN SIZE TO USE '   0     1  0     .000000   .0000 !  44 NO PICK     .000        0.      .0000000
  59.000000     .010000   99.000000 'MAX SIZE TO USE '   0     1  0     .000000   .0000 !  45 NO PICK     .000        0.      .0000000
ODFG REC   TYPE:  8
 2 SELECTIVITY PATTERN
  0   0   0   0   0   0   0  AGE TYPES USED
    .012387 -1  1  2 Q, QUANT, LOGERROR=1, BIO=1 or NUM=2
    .012387     .000100  100.000000 'ODF&G  CPUE Q    '   2     1  0     .000000   .0000 !  46 OK          .000 -763618.      .0000014
    .000000   -1.000000     .000000 'ODF&G  CPUE bioQ'   0     1  0     .000000   .0000 !  47 NO PICK     .000        0.      .0000000
   1.00000       .32 'ODF&G (BODENMILLER) '  ! # = 16 VALUE:       8.78999
   1.000000     .001000   40.000000 'USE SELEX FROM 1'   0     1  0     .000000   .0000 !  48 NO PICK     .000        0.      .0000000
  19.000000     .050000   99.000000 'MIN SIZE TO USE '   0     1  0     .000000   .0000 !  49 NO PICK     .000        0.      .0000000
  59.000000     .010000   99.000000 'MAX SIZE TO USE '   0     1  0     .000000   .0000 !  50 NO PICK     .000        0.      .0000000
CA RECFI   TYPE:  9
 2 SELECTIVITY PATTERN
  0   0   0   0   0   0   0  AGE TYPES USED
    .000331 -1  1  2 Q, QUANT, LOGERROR=1, BIO=1 or NUM=2
    .000331     .000100  100.000000 'CA-REC CPUE Q    '   2     1  0     .000000   .0000 !  51 OK          .000*********       .0000000
    .000000   -1.000000     .000000 'CA-REC CPUE bioQ'   0     1  0     .000000   .0000 !  52 NO PICK     .000        0.      .0000000
   1.00000       .34 'CALIFORNIA RECFIN   '  ! # = 17 VALUE:       8.39146
   4.000000     .001000   40.000000 'USE SELEX FROM 4'   0     1  0     .000000   .0000 !  53 NO PICK     .000        0.      .0000000
  19.000000     .050000   99.000000 'MIN SIZE TO USE '   0     1  0     .000000   .0000 !  54 NO PICK     .000        0.      .0000000
  59.000000     .010000   99.000000 'MAX SIZE TO USE '   0     1  0     .000000   .0000 !  55 NO PICK     .000        0.      .0000000
CDFG REC   TYPE: 10
 2 SELECTIVITY PATTERN
  0   0   0   0   0   0   0  AGE TYPES USED
    .001621 -1  1  2 Q, QUANT, LOGERROR=1, BIO=1 or NUM=2
    .001621     .000100  100.000000 'CDF&G  CPUE Q    '   2     1  0     .000000   .0000 !  56 OK          .000*********       .0000000
    .000000   -1.000000     .000000 'CDF&G  CPUE bioQ'   0     1  0     .000000   .0000 !  57 NO PICK     .000        0.      .0000000
   1.00000       .43 'CDF&G (WILSON-VAND) '  ! # = 18 VALUE:       1.98266
   4.000000     .001000   40.000000 'USE SELEX FROM 4'   0     1  0     .000000   .0000 !  58 NO PICK     .000        0.      .0000000
  19.000000     .050000   99.000000 'MIN SIZE TO USE '   0     1  0     .000000   .0000 !  59 NO PICK     .000        0.      .0000000
  59.000000     .010000   99.000000 'MAX SIZE TO USE '   0     1  0     .000000   .0000 !  60 NO PICK     .000        0.      .0000000
 1 AGEERR: 1: MULTINOMIAL,  0: S(LOG(P))=CONSTANT,  -1: S=P*Q/N
300.000 : MAX N FOR MULTINOMIAL
 3 1=%CORRECT, 2=C.V., 3=%AGREE, 4=READ %AGREE @AGE
    .600000     .300000     .950000 '%AGREE @ 2 (MIN)'   0     1  0     .000000   .0000 !  61 NO PICK     .000        0.      .0000000
    .100000     .100000     .900000 '%AGREE @ 25(MAX)'   0     1  0     .000000   .0000 !  62 NO PICK     .000        0.      .0000000
   1.000000     .001000    4.000000 'POWER           '   0     1  0     .000000   .0000 !  63 NO PICK     .000        0.      .0000000
    .150000     .010000     .300000 'OLD DISCOUNT    '   0     1  0     .000000   .0000 !  64 NO PICK     .000        0.      .0000000
    .000000     .001000     .100000 '%MIS-SEXED      '   0     1  0     .000000   .0000 !  65 NO PICK     .000        0.      .0000000
 0 END OF EFFORT
 0 FIX n FMORTs
 0  MATURITY
 1  GROWTH: 1=CONSTANT, 2=MORT. INFLUENCE
 5.0000 15.0000  AGE AT WHICH L1 AND L2 OCCUR
 1 1=NORMAL, 2=LOGNORMAL
  32.205317   10.000000   40.000000 'FEMALE L1       '   2     1  0   35.900000   .9000 !  66 OK          .000      -57.      .0232936
  47.953661   40.000000   70.000000 'FEMALE L2       '   2     1  0   46.580000   .9000 !  67 OK          .001      -47.      .0109405
    .202184     .100000     .400000 'FEMALE K        '   2     1  0     .149500   .9000 !  68 OK          .000   -34972.      .0000517
    .087900     .010000     .990000 'FEMALE CV5      '   0     1  0     .000000   .0000 !  69 NO PICK     .000        0.      .0000000
    .088200     .010000     .990000 'FEMALE CV15     '   0     1  0     .000000   .0000 !  70 NO PICK     .000        0.      .0000000
  31.883448   10.000000   70.000000 'MALE L1         '   2     1  0   35.390000   .9000 !  71 OK          .000      -71.      .0222675
  45.391235   20.000000   50.000000 'MALE L2         '   2     1  0   44.060000   .9000 !  72 OK          .000      -79.      .0287774
    .197926     .100000     .400000 'MALE K          '   2     1  0     .138400   .9000 !  73 OK          .000   -32650.      .0001236
    .082400     .010000     .990000 'MALE CV5        '   0     1  0     .000000   .0000 !  74 NO PICK     .000        0.      .0000000
    .064500     .010000     .990000 'MALE CV15       '   0     1  0     .000000   .0000 !  75 NO PICK     .000        0.      .0000000
         0  DEFINE MARKET CATEGORIES
 2 ENVIRONMENTAL FXN:    [-INDEX]  [FXN TYPE(1-4)]  [ENVVAR USED]
black.env
 -1  1  1
   1.000000     .050000     .950000 'CA INFLECTION   '   0     1  0     .000000   .0000 !  76 NO PICK     .000        0.      .0000000
 -2  1  1
   1.000000     .050000     .950000 'CA DESC SLOPE   '   0     1  0     .000000   .0000 !  77 NO PICK     .000        0.      .0000000
 4 ESTIMATE N ENVIRON VALUES
  -1945    1989       1
    .950000     .010000     .950000 '1978-89 INFLCT  '   2     1  0     .000000   .0000 !  78 BOUND       .000        0.      .0000000
  -1990    2002       1
    .010000     .010000     .950000 '1990-02 INFLCT  '   2     1  0     .000000   .0000 !  79 BOUND       .000        0.      .0000000
  -1945    1989       2
    .500000     .010000     .950000 '1978-89 SLOPE   '   2     1  0     .000000   .0000 !  80 OK          .000       -1.      .0000000
  -1990    2002       2
    .052562     .010000     .950000 '1990-02 SLOPE   '   2     1  0     .000000   .0000 !  81 OK          .000       -1.      .0000000
19 PENALTIES
     .00000       .30 ' penalty like       '  ! # = 19 VALUE:       -.30374
-1  1.0  1.0
 0 ENVIRONMENT EFFECT ON EXP(RECR)
20  STOCK-RECR
 3 1=B-H, 2=RICKER, 3=new B-H, 4=HOCKEY
 0 disabled option
     .10000      -.40 ' SPAWN-RECRUIT indiv'  ! # = 20 VALUE:      10.46796
     .00001      -.20 ' SPAWN-RECRUIT mean '  ! # = 21 VALUE:     -45.07477
    .243337     .100000    9.000000 'VIRGIN RECR MULT'   2     1  0     .000000   .0000 !  82 OK          .000   -61533.      .0000320
    .650000     .200000    1.000000 'B/H  S/R PARAM  '   0     1  0     .600000   .9000 !  83 NO PICK     .000        0.      .0000000
    .000000    -.200000     .200000 'BACKG. RECRUIT  '   0     1  0     .000000   .0000 !  84 NO PICK     .000        0.      .0000000
    .400000     .200000    1.500000 'S/R STD.DEV.    '   0     1  0     .000000   .0000 !  85 NO PICK     .000        0.      .0000000
    .000000    -.200000     .200000 'RECR TREND      '   0     1  0     .000000   .0000 !  86 NO PICK     .000        0.      .0000000
   1.000000     .500000    3.000000 'RECR. MULT.     '   0     1  0     .000000   .0000 !  87 NO PICK     .000        0.      .0000000
-1 INIT AGE COMP
   -.266361     .001000   10.000000 'RECR 1945 YC=43 '   0  1945  0     .000000   .0000 !  88 NO PICK     .000        0.      .0000000
   -.266361     .001000   10.000000 'RECR 1946 YC=44 '   0  1946  0     .000000   .0000 !  89 NO PICK     .000        0.      .0000000
   -.266361     .001000   10.000000 'RECR 1947 YC=45 '   0  1947  0     .000000   .0000 !  90 NO PICK     .000        0.      .0000000
   -.266361     .001000   10.000000 'RECR 1948 YC=46 '   0  1948  0     .000000   .0000 !  91 NO PICK     .000        0.      .0000000
   -.266286     .001000   10.000000 'RECR 1949 YC=47 '   0  1949  0     .000000   .0000 !  92 NO PICK     .000        0.      .0000000
   -.266143     .001000   10.000000 'RECR 1950 YC=48 '   0  1950  0     .000000   .0000 !  93 NO PICK     .000        0.      .0000000
   -.265939     .001000   10.000000 'RECR 1951 YC=49 '   0  1951  0     .000000   .0000 !  94 NO PICK     .000        0.      .0000000
   -.265680     .001000   10.000000 'RECR 1952 YC=50 '   0  1952  0     .000000   .0000 !  95 NO PICK     .000        0.      .0000000
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   -.265372      .001000    10.000000 'RECR 1953 YC=51 '   0  1953  0      .000000    .0000 !   96 NO PICK     .000        0.         .0000000
   -.265016      .001000    10.000000 'RECR 1954 YC=52 '   0  1954  0      .000000    .0000 !   97 NO PICK     .000        0.         .0000000
   -.264614      .001000    10.000000 'RECR 1955 YC=53 '   0  1955  0      .000000    .0000 !   98 NO PICK     .000        0.         .0000000
   -.264166      .001000    10.000000 'RECR 1956 YC=54 '   0  1956  0      .000000    .0000 !   99 NO PICK     .000        0.         .0000000
   -.263672      .001000    10.000000 'RECR 1957 YC=55 '   0  1957  0      .000000    .0000 !  100 NO PICK     .000        0.         .0000000
   -.263169      .001000    10.000000 'RECR 1958 YC=56 '   0  1958  0      .000000    .0000 !  101 NO PICK     .000        0.         .0000000
   -.262592      .001000    10.000000 'RECR 1959 YC=57 '   0  1959  0      .000000    .0000 !  102 NO PICK     .000        0.         .0000000
   -.261978      .001000    10.000000 'RECR 1960 YC=58 '   0  1960  0      .000000    .0000 !  103 NO PICK     .000        0.         .0000000
   -.261368      .001000    10.000000 'RECR 1961 YC=59 '   0  1961  0      .000000    .0000 !  104 NO PICK     .000        0.         .0000000
   -.260869      .001000    10.000000 'RECR 1962 YC=60 '   0  1962  0      .000000    .0000 !  105 NO PICK     .000        0.         .0000000
   -.260392      .001000    10.000000 'RECR 1963 YC=61 '   0  1963  0      .000000    .0000 !  106 NO PICK     .000        0.         .0000000
   -.260056      .001000    10.000000 'RECR 1964 YC=62 '   0  1964  0      .000000    .0000 !  107 NO PICK     .000        0.         .0000000
   -.259760      .001000    10.000000 'RECR 1965 YC=63 '   0  1965  0      .000000    .0000 !  108 NO PICK     .000        0.         .0000000
   -.259341      .001000    10.000000 'RECR 1966 YC=64 '   0  1966  0      .000000    .0000 !  109 NO PICK     .000        0.         .0000000
   -.258995      .001000    10.000000 'RECR 1967 YC=65 '   0  1967  0      .000000    .0000 !  110 NO PICK     .000        0.         .0000000
   -.258499      .001000    10.000000 'RECR 1968 YC=66 '   0  1968  0      .000000    .0000 !  111 NO PICK     .000        0.         .0000000
   -.257838      .001000    10.000000 'RECR 1969 YC=67 '   0  1969  0      .000000    .0000 !  112 NO PICK     .000        0.         .0000000
   -.257070      .001000    10.000000 'RECR 1970 YC=68 '   0  1970  0      .000000    .0000 !  113 NO PICK     .000        0.         .0000000
   -.256543      .001000    10.000000 'RECR 1971 YC=69 '   0  1971  0      .000000    .0000 !  114 NO PICK     .000        0.         .0000000
   -.255686      .001000    10.000000 'RECR 1972 YC=70 '   0  1972  0      .000000    .0000 !  115 NO PICK     .000        0.         .0000000
   -.254556      .001000    10.000000 'RECR 1973 YC=71 '   0  1973  0      .000000    .0000 !  116 NO PICK     .000        0.         .0000000
   -.253755      .001000    10.000000 'RECR 1974 YC=72 '   0  1974  0      .000000    .0000 !  117 NO PICK     .000        0.         .0000000
    .109561      .001000    10.000000 'RECR 1975 YC=73 '   2  1975  0      .000000    .0000 !  118 OK          .000     -806.         .0000675
    .160245      .001000    10.000000 'RECR 1976 YC=74 '   2  1976  0      .000000    .0000 !  119 OK          .000     -915.         .0097413
    .213998      .001000    10.000000 'RECR 1977 YC=75 '   2  1977  0      .000000    .0000 !  120 OK          .000    -1048.         .0045804
    .357964      .001000    10.000000 'RECR 1978 YC=76 '   2  1978  0      .000000    .0000 !  121 OK          .000    -1175.         .0052427
    .218143      .001000    10.000000 'RECR 1979 YC=77 '   2  1979  0      .000000    .0000 !  122 OK          .000    -1380.         .0041170
    .200936      .001000    10.000000 'RECR 1980 YC=78 '   2  1980  0      .000000    .0000 !  123 OK          .000    -1621.         .0024019
    .211916      .001000    10.000000 'RECR 1981 YC=79 '   2  1981  0      .000000    .0000 !  124 OK          .000    -1819.         .0021780
    .212332      .001000    10.000000 'RECR 1982 YC=80 '   2  1982  0      .000000    .0000 !  125 OK          .000    -2087.         .0024070
    .184095      .001000    10.000000 'RECR 1983 YC=81 '   2  1983  0      .000000    .0000 !  126 OK          .000    -2341.         .0018429
    .253921      .001000    10.000000 'RECR 1984 YC=82 '   2  1984  0      .000000    .0000 !  127 OK          .000    -2415.         .0014075
    .197326      .001000    10.000000 'RECR 1985 YC=83 '   2  1985  0      .000000    .0000 !  128 OK          .000    -2518.         .0010742
    .332860      .001000    10.000000 'RECR 1986 YC=84 '   2  1986  0      .000000    .0000 !  129 OK          .000    -2396.         .0011821
    .259766      .001000    10.000000 'RECR 1987 YC=85 '   2  1987  0      .000000    .0000 !  130 OK          .000    -2906.         .0007819
    .163137      .001000    10.000000 'RECR 1988 YC=86 '   2  1988  0      .000000    .0000 !  131 OK          .000    -3788.         .0006145
    .211015      .001000    10.000000 'RECR 1989 YC=87 '   2  1989  0      .000000    .0000 !  132 OK          .000    -3596.         .0005194
    .225745      .001000    10.000000 'RECR 1990 YC=88 '   2  1990  0      .000000    .0000 !  133 OK          .000    -3425.         .0005479
    .269205      .001000    10.000000 'RECR 1991 YC=89 '   2  1991  0      .000000    .0000 !  134 OK          .000    -3124.         .0006827
    .286802      .001000    10.000000 'RECR 1992 YC=90 '   2  1992  0      .000000    .0000 !  135 OK          .000    -2934.         .0010812
    .256612      .001000    10.000000 'RECR 1993 YC=91 '   2  1993  0      .000000    .0000 !  136 OK          .000    -2782.         .0011450
    .306006      .001000    10.000000 'RECR 1994 YC=92 '   2  1994  0      .000000    .0000 !  137 OK          .000    -2200.         .0008823
    .320357      .001000    10.000000 'RECR 1995 YC=93 '   2  1995  0      .000000    .0000 !  138 OK          .000    -1636.         .0009894
    .466513      .001000    10.000000 'RECR 1996 YC=94 '   2  1996  0      .000000    .0000 !  139 OK          .000    -1064.         .0014291
    .400217      .001000    10.000000 'RECR 1997 YC=95 '   2  1997  0      .000000    .0000 !  140 OK          .000    -1001.         .0019302
    .183228      .001000    10.000000 'RECR 1998 YC=96 '   2  1998  0      .000000    .0000 !  141 OK          .000    -1289.         .0016850
   -.209138      .001000    10.000000 'RECR 1999 YC=97 '   0  1999  0      .000000    .0000 !  142 NO PICK     .000        0.         .0000000
   -.211659      .001000    10.000000 'RECR 2000 YC=98 '   0  2000  0      .000000    .0000 !  143 NO PICK     .000        0.         .0000000
   -.216347      .001000    10.000000 'RECR 2001 YC=99 '   0  2001  0      .000000    .0000 !  144 NO PICK     .000        0.         .0000000
   -.223402      .001000    10.000000 'RECR 2002 YC=00 '   0  2002  0      .000000    .0000 !  145 NO PICK     .000        0.         .0000000
 CONVERGENCE
LIKE CHANGE:      .0002  MAX PARM CHANGE: 118    RECR 1975 YC=73    .00170
CONVERGENCE PATH (LIKE, BIOMASS)
 -1232.8303     10463.0
 -1232.8303     10463.6
 -1232.8302     10467.1
 -1232.8300     10469.5
 -1232.8299     10466.8
 -1232.8292     10455.2
 -1232.8290     10447.0
 NUMBER OF ESTIMATED PARAMETERS =          61
 N CATCHES WITH F ESTIMATED     =         342
 N SURV OBS WITH EMPH > 0.001   =          63
 N EFFORT OBS WITH EMPH > 0.001 =           0
 N COMPOSITION OBS WITH NAGES>1 =         113
 N COMPOSITION BINS WITH DATA   =        2603

 PARAMETERS ON BOUNDS
  12    .05000     F-descend inflec
  36    .05000     F-descend inflec
  78    .95000     1978-89 INFLCT
  79    .01000     1990-02 INFLCT

 PARAMETERS WITH FLAT CURVATURE (BAD SECOND DERIV)
  12    .05000     F-descend inflec
  36    .05000     F-descend inflec
  78    .95000     1978-89 INFLCT
  79    .01000     1990-02 INFLCT

PARAMETER pairs with SCALED HESSIAN or CORRELATION > 0.7
  9  10     Size@ascend infl    Ascending slope    -.8175  -.6246
 11  13     F-max size selec    F-descend slope     .8753   .6742
 12  13     F-descend inflec    F-descend slope  -1.0000-99.0000
 16  17     Size@ascend infl    Ascending slope    -.8235  -.7530
 22  23     Size@ascend infl    Ascending slope    -.7061  -.6336
 33  34     Size@ascend infl    Ascending slope    -.8541  -.8481
 35  37     F-max size selec    F-descend slope     .8908   .5960
 36  37     F-descend inflec    F-descend slope  -1.0000-99.0000
 39  40     Size@ascend infl    Ascending slope    -.8205  -.7163
 67  68     FEMALE L2           FEMALE K           -.7149   .5311
 78  82     1978-89 INFLCT      VIRGIN RECR MULT -1.0000-99.0000
 78 118     1978-89 INFLCT      RECR 1975 YC=73    -.8208-99.0000
 78 119     1978-89 INFLCT      RECR 1976 YC=74    -.7714-99.0000
 82 118     VIRGIN RECR MULT    RECR 1975 YC=73    -.8198  5.0204
 82 119     VIRGIN RECR MULT    RECR 1976 YC=74    -.7722  -.0217
118 119     RECR 1975 YC=73     RECR 1976 YC=74    -.8858 -7.1573
118 120     RECR 1975 YC=73     RECR 1977 YC=75    -.7871  6.8833
119 120     RECR 1976 YC=74     RECR 1977 YC=75    -.9114  -.5821
119 121     RECR 1976 YC=74     RECR 1978 YC=76    -.7427   .0635
120 121     RECR 1977 YC=75     RECR 1978 YC=76    -.8838  -.6237
121 122     RECR 1978 YC=76     RECR 1979 YC=77    -.8478  -.5928
122 123     RECR 1979 YC=77     RECR 1980 YC=78    -.8090  -.5507
123 124     RECR 1980 YC=78     RECR 1981 YC=79    -.7828  -.3088
124 125     RECR 1981 YC=79     RECR 1982 YC=80    -.7601  -.6858
125 126     RECR 1982 YC=80     RECR 1983 YC=81    -.7278  -.6840
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